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NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
RESERVOIR DAM (ME 004. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV SEP 81

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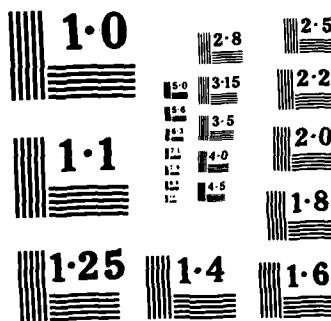
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MAP



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

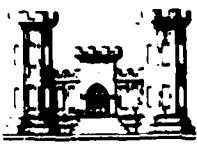
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KENNEBEC RIVER BASIN
Waterville, Maine

(2)

RESERVOIR DAM ME 00472

PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM



JUL 05 1985

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
Waltham, Massachusetts 02154

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is a small earthfill, concrete core dam located in central Maine about 2 miles north of Waterville. The dam is 735 ft. long and 27 ft. high. The visual inspection showed that the dam and its appurtenant structures are in good condition. It is small in size with a high hazard classification. Remedial measure include routine general maintenance to keep the vegetation trimmed among a few others.		

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

SEP 30 1981

Honorable Joseph E. Brennan
Governor of the State of Maine
State Capitol
Augusta, Maine 04330

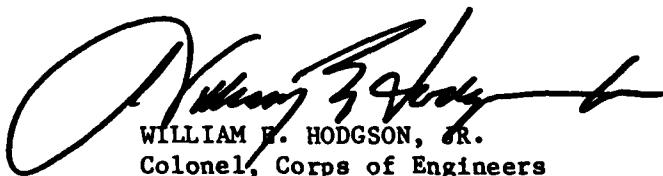
Dear Governor Brennan:

Inclosed is a copy of the Reservoir Dam (ME-00472) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Agriculture and to the owner, Kennebec Water District. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Agriculture for your cooperation in this program.

Sincerely,



WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting, Division Engineer

Incl
As stated

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NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No. : ME 00472
Name of Dam : Reservoir Dam
Town : Waterville, ME.
County & State : Kennebec & Somerset Counties, Maine
Stream : Unnamed (Tributary to Kennebec River)
Date of Inspection : November 16, 1979

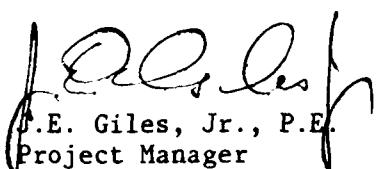
BRIEF ASSESSMENT

Reservoir Dam is a small earthfill, concrete core dam located in central Maine about two miles north of Waterville. The dam was built to supplement the water supply of the Kennebec Water District. It is essentially a pumped storage project with all of the storage (with the exception of direct precipitation) being pumped into the reservoir from China Lake about 10 miles away. The original structure was built in 1918 but it was enlarged in 1951 so as to double the reservoir storage capacity. The Kennebec Water District owns the dam. They also maintain and monitor the project on a regular basis. The project includes the main dam which is 735 feet long and 27 feet high, a dike along the upper reaches of the reservoir, and a runoff diversion ditch around the perimeter of the project.

The visual inspection showed that the dam and its apurtenant structures are in good condition. With a maximum storage capacity of 156 acre-feet and height of 27 feet it is classified as a small dam. Results from the dam breach analysis determined that the structure should be classified as a high hazard potential because more than a few lives would be threatened in the event of a dam breach.

A test flood was estimated for the Reservoir Dam using the "Preliminary Guidance for Estimating Maximum Probable Discharges in Phase I Safety Investigations", New England Division Corps of Engineers, March 1978. It was assumed that the dike system surrounding the project would prevent any runoff from entering the reservoir during a PMF event. Therefore, only direct precipitation was considered during a Probable Maximum Precipitation (PMP) storm. This resulted in the water level being increased by 1.6 feet to elevation 328.6. This increase when added to the normal water level elevation of 327 would remain below the crest of the dam at Elevation 330 but it would exceed the top of the perimeter dike at Elevation 328.

No urgent or emergency actions are required for Reservoir Dam based on this inspection. Remedial measures include routine general maintenance to keep the vegetation trimmed, monitoring the project during periods of intense rainfall, establishing a monthly visual inspection program, and developing a downstream warning system.

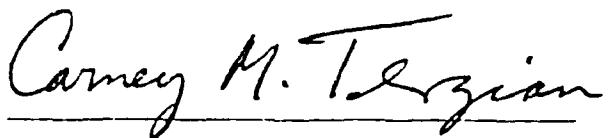


J.E. Giles, Jr., P.E.
Project Manager
Massachusetts Registration No. 1643

This Phase I Inspection Report on **Reservoir Dam (ME-00472)** has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.



ARAMAST MANTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

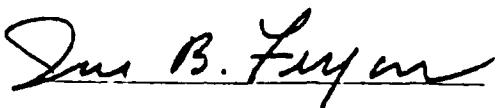


CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division



JOSEPH W. FINEGAN, JR., CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:



JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project compliance with OSHA rules and regulations is also excluded.

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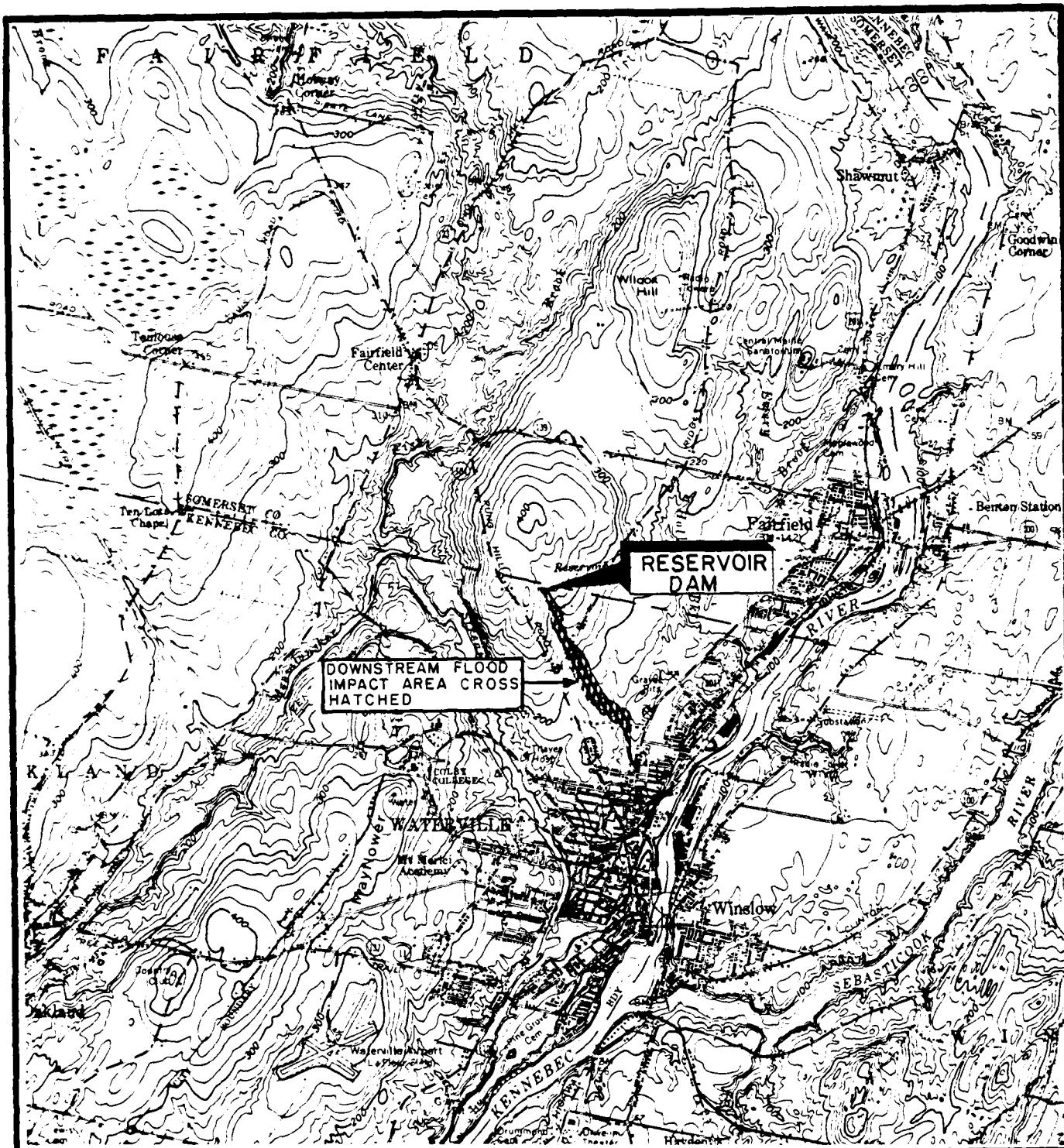
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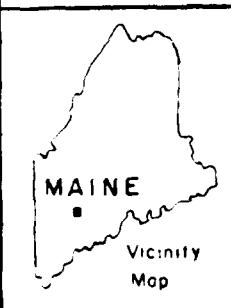


RESERVOIR DAM

View From Right Abutment



FROM USGS WATERVILLE, ME.
15MIN. QUADRANGLE MAP



1/2 0 Miles

SCALE: 1"=1MILE

RESERVOIR DAM LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

DATE SEPT. 1981

MAIN

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NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

RESERVOIR DAM
KENNEBEC AND SOMERSET COUNTIES, MAINE

SECTION I
PROJECT INFORMATION

1.1 General

a. Authority - Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Chas. T. Main, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Maine. Authorization and notice to proceed were issued to Chas. T. Main, Inc. under a letter of November 6, 1979 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW 33-80-C-0011 has been assigned by the Corps of Engineers for this work.

b. Purpose

- (1) The purposes of the inspection program are: To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
- (2) To encourage and prepare the states to initiate effective dam safety programs for non-Federal dams.
- (3) To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

- (1) Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.
- (2) A field inspection of the facility detailing the visual condition of the dam, embankments and appurtenant structures.
- (3) Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.
- (4) An assessment of the condition of the facility and corrective measures required.

It should be noted that this report does not pass judgment on the safety or stability of the dam other than on a visual basis. The inspection is to identify those features of the dam which need corrective action and/or further study.

1.2 Description of Project

- a. Location - Reservoir Dam is located on the Somerset and Kennebec County Line on an unnamed stream, approximately 1.75 miles above the Kennebec River and two miles north of Waterville. The dam location is included on U.S.G.S. 15 minute series Quadrangle, Waterville, Maine with approximate coordinates of N44°35'0", W69°38'40".
- b. Description of Dam and Appurtenances - The project consists of three main features; an earthfill concrete core dam, an earthfill dike, and a runoff diversion ditch. The dam is approximately 735 feet long, 27 feet high, and 12 feet wide at the crest (Elev. 330 NGVD) with upstream and downstream slopes of 1.5 H:1V. The reinforced concrete core wall is 16 inches thick with a 3' x 3' footing that rests on a rock foundation. The top of the wall is five feet lower than the crest of the dam. The upstream face of the dam is protected with rip-rap and the downstream face has a heavy grass cover with a drainage ditch running along the toe.

The earthfill dike extends around the reservoir adjoining the dam at both abutments. It was installed in 1951 to double the storage capacity of the reservoir. The height of the dike varies but the crest is at constant Elevation 328 NGVD. The embankment slope is 2:1 on the reservoir side with a rip-rap cover and 3:1 on the dry side which has a well established grass cover.

Running completely around the project is a runoff diversion ditch. The purpose of this ditch is to prevent any surface run-off from entering and contaminating the reservoir supply.

Two inlet lines, one 24" and one 20" diameter pipes supply water to the reservoir. Two outlet lines, one 16" and one 12" diameter pipes carry the discharge as needed. A 14" line installed when the original dam construction took place in 1918 was closed in 1951. The gate valves on both lines are normally left open to maintain the water pressure in the system and to facilitate water supply operations. The flow within these pipelines, whether filling or emptying the reservoir, is controlled by the Kennebec Water District through its pump house controls located 180 feet downstream from the dam. The source of supply for the reservoir is China Lake located 10 miles southeast of the dam with a drainage area of 36 square miles.

A 14" diameter open pipe serves as an overflow outlet with Invert Elevation 327 NGVD. It has a small concrete receptacle at the inlet and empties into the drainage ditch at the toe of the dam.

- c. Size Classification - The maximum embankment height is approximately 27 feet above the downstream toe and the maximum storage is 145 acre-feet at the crest of the dike. This classifies the structure as a small dam (less than 1000 acre feet) in accordance with the Corps of Engineers Recommended Guidelines for Safety Inspection of Dams.
- d. Hazard Classification - This facility is classified as a high hazard potential dam based on the potential for loss of more than a few lives in the event of a dam failure in several occupied dwellings downstream of the dam.
- e. Ownership - The dam and associated works are owned by the Kennebec Water District.
- f. Operators - The project is operated and maintained by the Kennebec Water District. The District Superintendent is Mr. Theodore Rohman in Waterville, Telephone (207) 872-2763.
- g. Purpose of Dam - Reservoir Dam was constructed to supply a secondary water supply source for the Kennebec Water District. The reservoir is entirely contained; surface runoff is diverted around it. The reservoir is supplied through a pipeline distribution network from China Lake.
- h. Design and Construction History - The original dam was built in 1918 by the firm of Mr. James H. Kerr of Rumford, Maine. It was designed by Metcalf and Eddy Consulting Engineers from Boston. In 1951, the dam was enlarged and the dike was added so as to double the storage capacity. This work was performed by A. P. Wyman, Inc. of Waterville, Maine, with the engineering supervised by Mr. J. Elliot

Hale. Then in 1978, some minor revisions were performed on the project when the gunite facing was replaced by rip-rap.

- i. Normal Operating Procedures - Water is pumped from the China Lake pipe line into the Water Districts distribution pipes, and if the rate of pumping exceeds the consumption at the moment, the excess flows into the reservoir; conversely, if the consumption exceeds the pumping rate, water is drawn from the reservoir to make up the difference. The reservoir thus serves as an equalizer, and assists in the maintenance of a uniform pressure in the pipes. The water level at the reservoir is monitored and recorded on a continuous weekly chart. Normal operating level is between Elevations 327 and 325.

1.3 Pertinent Data

- a. Drainage Area - Reservoir Dam controls a drainage area of 0.25 square miles. Runoff from the upstream drainage area is diverted around the reservoir. Thus, runoff drainage is not considered when evaluating the hydrologic conditions of this dam.

b. Discharge at Damsite

- (1) Outlet Works - The storage is discharged through a 24" diameter and 14" diameter pipe controlled by the pumphouse equipment at the downstream end. The invert elevation of the 24" is 316 and of the 14" is 302. Also, a 14" diameter open overflow pipe is at invert Elevation 327.

- (2) Maximum known flood - Unavailable in existing data.

c. Elevations (feet above NGVD)

(1) Streambed at toe of dam	303
(2) Bottom of cutoff	295
(3) Maximum tailwater	Not available
(4) Normal Pool	327
(5) Full flood control pool	Not applicable
(6) Spillway crest (overflow pipe)	327
(7) Design surcharge (Original Design)	Not available
(8) Top of upstream dike	328
(9) Top of dam	330

	(10) Test flood surcharge	328.6
d. <u>Reservoir</u> (Length in feet)		
(1) Normal pool @ Elev. 327	230	
(2) Flood control pool	Not applicable	
(3) Spillway crest pool	230	
(4) Top of dam	230	
(5) Test flood pool	230	
e. <u>Storage</u> (acre-feet)		
(1) Normal Pool	128	
(2) Flood control pool	Not applicable	
(3) Spillway crest pool	128	
(4) Top of dike	145	
(5) Test flood pool	156	
f. <u>Reservoir Surface</u> (acres)		
(1) Normal Pool	11.1	
(2) Flood-control pool	Not applicable	
(3) Spillway crest	11.1	
(4) Test flood pool	11.4	
(5) Top of dam	12.0	
g. <u>Dam and Dike</u>	<u>Dam</u>	<u>Dike</u>
(1) Type	Earthfill concrete core	Earthfill
(2) Length	735 feet	1,535 ft.
(3) Height	27 feet	Varies
(4) Top Width	12 feet	12 ft.

	<u>DAM</u>	<u>DIKE</u>
(5) Side Slopes	Upstream 1.5:1	Upstream 2.0:1
	Downstream 1.5:1	Downstream 3.0:1
(6) Zoning	None	None
(7) Impervious Core	Concrete	None
(8) Cutoff	Concrete	None
(9) Grout curtain	None	None
(10) Other	Rip-rap face	Rip-rap face
h. <u>Diversion and Regulating Tunnel</u> - None		
i. <u>Principal Outlet Works</u>		
(1) Invert - 327' NGVD		
(2) Size ~ 14" Dia.		
(3) Description - Overflow control		
(4) Control Mechanism - Open - No valves		
(5) Other - None		
j. <u>Regulating Outlets</u>		
(1) i. Invert - 302' NGVD		
ii. Size - 20" Dia.		
iii. Description - Inlet & Outlet Supply Pipeline		
iv. Control Mechanism - Pumps located downstream govern flow; check valve in valve chamber on dam.		
(2) i. Invert - 316' NGVD		
ii. Size - 24" Dia.		
iii. Description - Inlet & Outlet Supply Pipeline		
iv. Control Mechanism - Pumps located downstream govern flow; check valve located 180' downstream.		

SECTION 2

ENGINEERING DATA

2.1 Design

Metcalf & Eddy Consulting Engineers from Boston Massachusetts, were the engineers responsible for designing the original Reservoir Dam structure. Three of their original drawings were obtained and are included in Appendix B. Also, the report from Metcalf & Eddy to the Trustees of the Kennebec Water District; Re., "Necessity and Approximate Cost of a New Distributing Reservoir", August 3, 1916, was reviewed in preparing this report. Two additional drawings showing the 1951 revisions were obtained and are in Appendix B. The Contract and Specifications for "Improvements to Reservoir for Kennebec Water District", March 1, 1951, were reviewed. Also, the Trustees' Statements from 1917, 1919 and 1951 were received from the Kennebec Water District. Unfortunately, design calculations from neither the 1918 nor 1951 construction were available in preparing this report.

The general design of the dam is an earthfill structure with a concrete core wall down to bedrock. The 16" thick reinforced wall has a 3' x 3' concrete base which sets on a rock foundation. The embankment slopes were originally 2.5:1 and 2:1 on the upstream and downstream slopes respectively but these were changed in 1951 such that both slopes are now 1.5:1.

2.2 Construction

There are no actual records of the original or revised construction other than the report from the Kennebec Water District. The earthfill was taken from the reservoir area which, according to Metcalf and Eddy, was a clayey hardpan, extremely hard and laid in layers with the "best selected material" forming the upstream embankment and the "second grade material" forming the downstream embankment. The original dam was built by the firm of Mr. James H. Kerr from Rumford, Maine. The 1951 changes were performed by A. P. Wyman, Inc. of Waterville, Maine.

2.3 Operation

The daily level of the reservoir is monitored and recorded by the Kennebec Water District. The level of the reservoir is maintained between Elevations 325 and 327 under normal use. The water level is mechanically controlled by the pumps and valves within the Water District's distribution network. The pipeline pressure at the pumping station downstream from the dam is approximately 110 p.s.i. due to the pressure head from the reservoir. During low usage when it is not economical to run the systems

large pumps, the reservoir becomes the major source of water supply, taking advantage of its pressure head for distribution.

2.4 Evaluation

- a. Availability: All of the engineering data acquired was received from the Kennebec Water District. This includes the drawings, reports, and miscellaneous material. All of the drawings received are included in Appendix B.
- b. Adequacy: The limited amount of engineering data did not allow for a definitive review. Evaluation must be based on visual inspection, past performance history, and engineering judgment.
- c. Validity: The field inspection indicated that the external features of the dam and appurtenances substantially agree with those shown on the available drawings.

SECTION 3
VISUAL INSPECTION

3.1 Findings

- a. General - The field inspection was conducted by Mr. L. Seward and Mr. J. Jonas of Chas. T. Main, Inc. on 16 November 1979 and J. E. Giles, Jr. on March 10, 1981. On the dates of inspection, the Reservoir Dam was in good condition. General maintenance of the project is necessary but no urgent or emergency actions are required at this time.
- b. Dam
 - (1) Crest - The embankment crest was true to line with no apparent dips, sags, cracks or other evidence of distress (Photo 1 & Overview). The crest has a well established grass cover with no signs of trespassing.
 - (2) Upstream slopes - The upstream face was in very good condition with an undamaged rip-rap cover (Photos 1, 2 3 & Overview).
 - (3) Downstream slope - The downstream slope is dry with a heavy, well established grass cover (Photo 4). The slope showed no signs of lateral movement, erosion, sagging, or slides. No seepage was observed. The grass and weeds appeared overgrown and uncut but in general the slope was in good condition.
 - (4) Downstream toe - No boils or seeps were observed. The drainage ditch running along the toe contained a small amount of running water from upstream of the reservoir. The flow was approximately ten gals per minute. It appeared in good condition although somewhat overgrown with cattails, brambles, and other weeds.
 - (5) Underdrain system - The dam has no underdrain system.
 - (6) Instrumentation - The only instrument at the project is the water level device which was not observed during the inspection. A copy of a weekly chart which records the water level was made available and is included in Appendix B.
- c. Appurtenent Structures
 - (1) Dike - The dike surrounding the upper part of the reservoir and adjoining the dam abutments was in good condition. It has no apparent dips, sags, or other evidence of distress along the crest. There was no evidence of seepage. The crest and dry-side slopes did have a well-established grass cover. The embankment had a very good rip-rap cover along the entire length.

(2) Intercepting ditch - The intercepting or diversion ditch completely surrounds the project. At the time of inspection it had a small amount of water flowing through it. Most of this water flowed along the western side of the reservoir with only a trickle flowing along the eastern side. The ditch appeared to be functioning properly, that is, diverting the surface runoff around the reservoir.

(3) Inlet and outlet works - Because both supply and outlet lines were buried and their inlets and outlets submerged, these were not able to be inspected. (See Section 7) The housing for the valve control for the 14" abandoned pipeline is unused with some rubbish accumulated at the bottom.

d. Reservoir Area

The reservoir looked very clean with no irregularities observed. On the northwest upstream end of the reservoir, outside of the dike but inside the diversion ditch, a small pool of relatively stagnant water was observed. It appeared that this shallow pool would occasionally spill over the dike (without damage) into the reservoir. Probably the result of rainwater, this pool is not a serious problem at present. (See Section 7)

e. Downstream Channel

There is a well-defined downstream channel below the dam with only a small flow consisting of the discharge from the diversion ditch around the project. There were no obstructions noted.

3.2 Evaluation

The dam, dike, reservoir, and diversion channel are all in good condition. The only points which should be checked are operability of the controls, the overgrowth of grass and weeds on the downstream slope and around the drainage ditch, and the pool of stagnant water at the northwest corner of the project.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

- a. General: Reservoir Dam is used exclusively for water supply. In-flow and outflow are based on water supply demand within the system. The fluctuation of the reservoir level is about two feet during normal operations with the maximum level controlled by an overflow pipe at Elevation 327 NGVD.
- b. Warning System: No warning system or emergency evacuation plans are in effect for this project. (See Section 7)

4.2 Maintenance Procedures

- a. General: The dam is maintained by the Kennebec Water District. The site is visited daily by members of the Kennebec Water District staff. Repairs and general maintenance are performed as required.
- b. Operating Facilities: At the project site, there are no manual operations necessary during normal use. The check valves on both supply lines are left open at all times and the reservoir level is monitored by a recording device.

4.3 Evaluation

The operational and maintenance procedures required at the Reservoir Dam are minimal. There does appear to be a lack of general slope maintenance, that is, keeping the grass and weeds trimmed.

SECTION 5

EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES

5.1 General - The runoff from the watershed area above Reservoir Dam is diverted around the reservoir. The dam is located approximately two miles above the town of Waterville Maine. The catchment area of the reservoir is 0.25 square miles. For the Test Flood Analysis the 24 hour Probable Maximum Precipitation (PMP) of 19 inches was used. This results in the dike being overtopped by about six inches.

5.2 Design Data - The dam embankment is approximately 735 feet long and 27 feet high with crest at Elevation 330 NGVD. The embankment has upstream and downstream slopes of 1.5:1. The capacity of the reservoir at various elevations was taken from a table used by the project operators.

5.3 Experience Data - No past hydrology data was available.

5.4 Test Flood Analysis - Because the reservoir is not subjected to runoff from the watershed area above it, the Test Flood Analysis was performed using only direct precipitation into the reservoir during a PMP event. The PMP for this portion of Maine is assumed to be 19 inches. The starting elevation of the reservoir prior to the PMP is taken as Elevation 327, the invert of the overflow pipe. The top of the dike is at Elevation 328 which means that approximately seven inches of water will overtop the dike. Of course, this is assuming that the overflow pipe is not passing any water which is not altogether realistic. Because of the small area of the reservoir together with the 12 inches of freeboard at the pool's maximum operating level, Reservoir Dam is expected to adequately control the Test Flood. However, it should be noted, the assumption that all of the upstream runoff will be diverted around the reservoir because of the dike and diversion channel may not be true. It is possible that some of the runoff will overtop the dike and enter the reservoir but a flood analysis to take this into account is beyond the scope of this report.

5.5 Dam Failure Analysis - The maximum water surface elevation of 328.6 feet and 156 acre-feet is considered in dam breach analysis. The impact of failure of the dam was assessed using the "Rule of Thumb Guidance for Estimating Downstream Dam Failure Hydrographs" prepared by the Corps of Engineers. The breach width was selected to be 35 percent of the length of the dam at mid-height 257 feet. The downstream discharge from the breach of the dam was estimated to be about 56,000 cfs. This discharge was routed downstream. At the northern end of Waterville, the flood surcharge will enter the residential section with an initial height of 4.4 feet and volume of 4000 cfs. It is felt that a wave of this size would cause considerable damage once it reached the town, especially if its flow were restricted when passing through the residential area. The downstream

flood impact area is outlined on the Location Map. Between the dam and the northern side of Waterville some 9,000 feet downstream (Reach 26), there are no residences or other structures which would be damaged by the dam breach surcharge. When the surcharge reaches the homes in the northern side of Waterville it is expected that serious property damage and loss of more than a few lives would result. For this reason, the dam has been classified as a high hazard potential.

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observation

The visual inspections of the Reservoir Dam on November 16, 1979 and March 10, 1981 revealed a sound structure with no evidence of instability. There were no dips, sags, or depressions observed in the embankment.

6.2 Design and Construction Data

Original design and construction data was not available in preparing this report.

6.3 Post Construction Changes

In 1951 the dam was raised five feet and the dike was added. In 1978, the gunite facing was replaced with a rip-rap cover. No other major structural changes were performed to the dam.

6.4 Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition - This inspection indicates that Reservoir Dam is in good condition including the dike and diversion ditch.
- b. Adequacy of Information - The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history and engineering judgment.
- c. Urgency - The remedial measures presented below should be implemented by the Owner within one year of receipt of this Phase I Inspection Report.

7.2 Recommendations

- a. Drain pool outside dike at north west corner of reservoir by connecting to the drainage ditch.
- b. Place shutoff valves inside the reservoir on both the two inlet and two outlet pipe lines.

7.3 Remedial Measures The owner should:

- a. Establish a formal downstream warning and evacuation plan to be implemented in the event of an emergency.
- b. Establish a system to monitor the project during periods of intense rainfall.
- c. Conduct a technical investigation of the project every two years.
- d. Obtain and maintain a set of as-built drawings and inspection reports.
- e. Periodically trim the grass and remove the weeds on the downstream slope and around the drainage channel.

7.4 Alternatives

There are no practical alternatives to the recommendations of Sections 7.2 and 7.3.

APPENDIX A

FIELD INSPECTION CHECK LIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Reservoir Dam, Waterville, MEDATE Nov. 16, 1979TIME 11:00 A.M.WEATHER Fair, Windy, 30°FA.S. ELEV. U.S. DN.S. PARTY:

Civil

1. Stanley S. Marshall, Engineer 6. _____2. Jan N. Jonas, Civil Engineer 7. _____3. J. E. Giles, Jr., Project Manager* 8. _____

4. _____ 9. _____

5. _____ 10. _____

PROJECT FEATURE	INSPECTED BY	REMARKS
1. All project features were inspected by each member of the inspection party.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

*at site March 10, 1981

INSPECTION CHECK LIST

PROJECT Reservoir Dam, Waterville, ME DATE Nov. 16, 1979PROJECT FEATURE Earthfill Dam-water sply NAME Stanley S. MarshallDISCIPLINE Hydro NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	330 feet
Current Pool Elevation	327 feet
Maximum Impoundment to Date	40,000,000 gallons (elev. 327)
Surface Cracks	None visible
Pavement Condition	Gravel
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Not applicable
Indications of Movement of Structural Items on Slopes	Not applicable
Trespassing on Slopes	None visible
Vegitation on Slopes	Some weeds and grass
Sloughing or Erosion of Slopes or Abutments	None visible
Rock Slope Protection - Riprap Failures	No failures visible
Unusual Movement or Cracking at or near Toes	None visible
Unusual Embankment or Downstream Seepage	None
Piping or Boils	None visible
Foundation Drainage Features	Runoff drainage ditch
Toe Drains	Same
Instrumentation System	None

INSPECTION CHECK LIST

PROJECT Reservoir Dam, Waterville, MEDATE Nov. 16, 1979PROJECT FEATURE EarthfillNAME Stanley S. MarshallDISCIPLINE HydroNAME Jan N. Jonas

AREA EVALUATED	CONDITION
<u>CULLET WORKS - DIVERSION CHANNEL AND INTAKE STRUCTURE</u>	
a. Approach Channel	
Slope Conditions	Not applicable - diversion ditch by-passes reservoir
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Not visible
Stop Logs and Slots	

INSPECTION CHECK LIST

PROJECT Reservoir Dam Waterville, MEDATE Nov. 16, 1979PROJECT FEATURE Earthfill DamNAME Stanley S. MarshallDISCIPLINE HydroNAME Jan N. Jonas

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - CONTROL TOWER</u>	
a. Concrete and Structural	Valve chamber in dam embankment
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	N/A
Float Wells	N/A
Crane Hoist	N/A
Elevator	N/A
Hydraulic System	N/A
Service Gates	Operability of check valve not known
Emergency Gates	N/A
Lightning Protection System	N/A
Emergency Power System	N/A
Wiring and Lighting System in Gate Chamber	N/A

INSPECTION CHECK LIST

PROJECT Reservoir Dam Waterville, ME DATE Nov. 16, 1979
 PROJECT FEATURE Earthfill Dam NAME Stanley S. Marshall
 DISCIPLINE Hydro NAME Jan N. Jonas

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - TRANSITION AND CONDUIT</u>	Not visible
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	
<u>DIKE EMBANKMENT</u>	
Crest Elevation	328 feet
Surface Cracks	None
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Trespassing on Slopes	None
Vegetation on Slopes	Heavily grassed
Sloughing or Erosion	None
Rip-rap Cover	Good
Seepage	None

INSPECTION CHECK LIST

PROJECT Reservoir Dam Waterville, MEDATE Nov. 16, 1979PROJECT FEATURE Earthfill DamNAME Stanley S. MarshallDISCIPLINE HydroNAME Jan N. Jonas

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u> General Condition of Concrete Rust or Staining Spalling Erosion or Cavitation Visible Reinforcing Any Seepage or Efflorescence Condition at Joints Drain holes Channel Loose Rock or Trees Overhanging Channel Condition of Discharge Channel	Not applicable

INSPECTION CHECK LIST

PROJECT Reservoir Dam Waterville, MEDATE Nov. 16, 1979PROJECT FEATURE Earthfill DamNAME Stanley S. MarshallDISCIPLINE HydroNAME Jan N. Jonas

AREA EVALUATED	CONDITION
<u>CUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	Not applicable
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	None
General Condition of Concrete	
Rust or Staining	
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Channel	N/A
Other Obstructions	None

INSPECTION CHECK LIST

PROJECT Reservoir Dam Waterville, MEDATE Nov. 16, 1979PROJECT FEATURE Earthfill DamNAME Stanley S. MarshallDISCIPLINE HydroNAME Jan N. Jonas

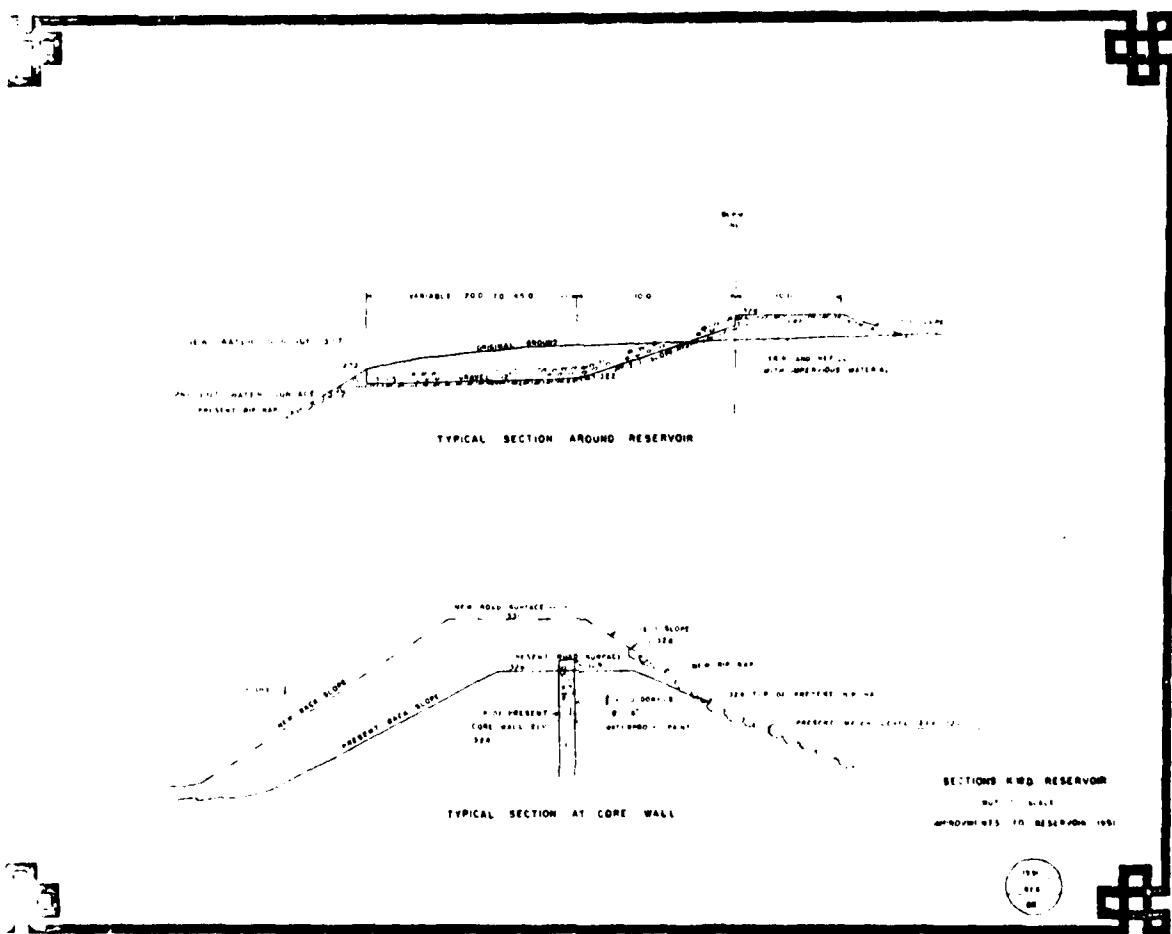
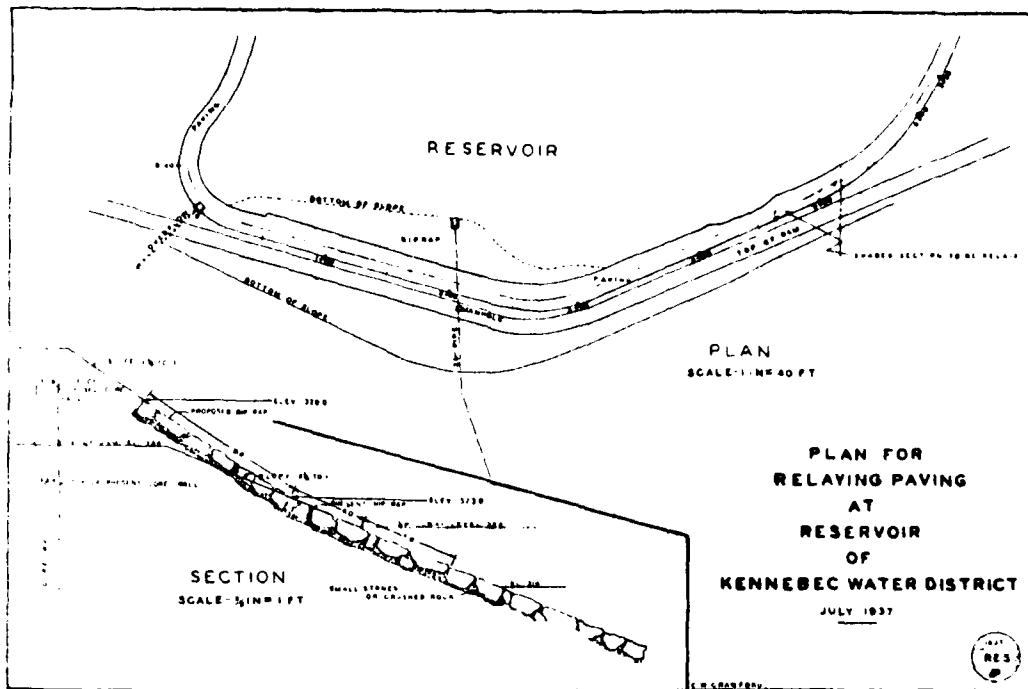
AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SERVICE BRIDGE</u>	
a. Super Structure	None
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

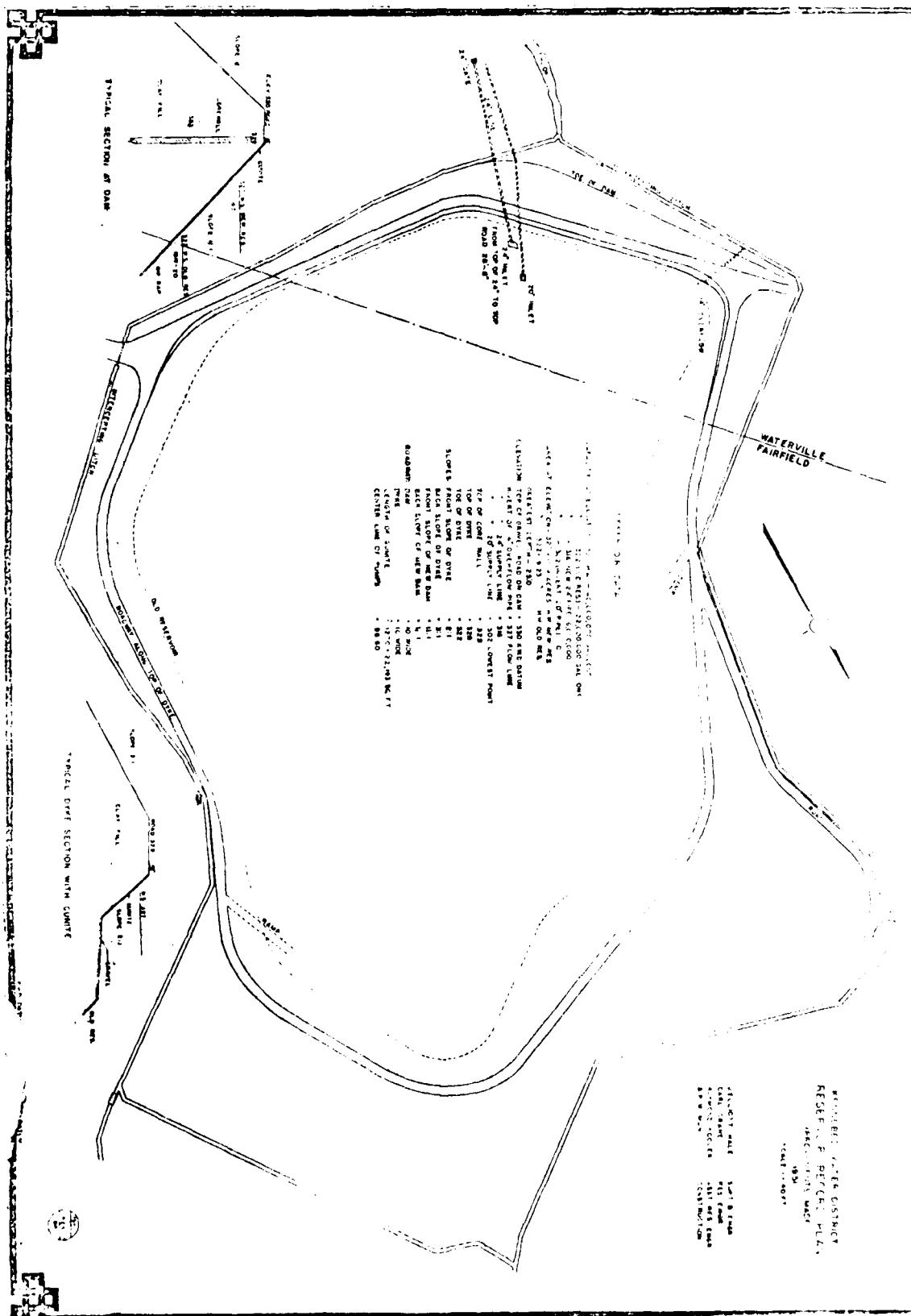
APPENDIX B

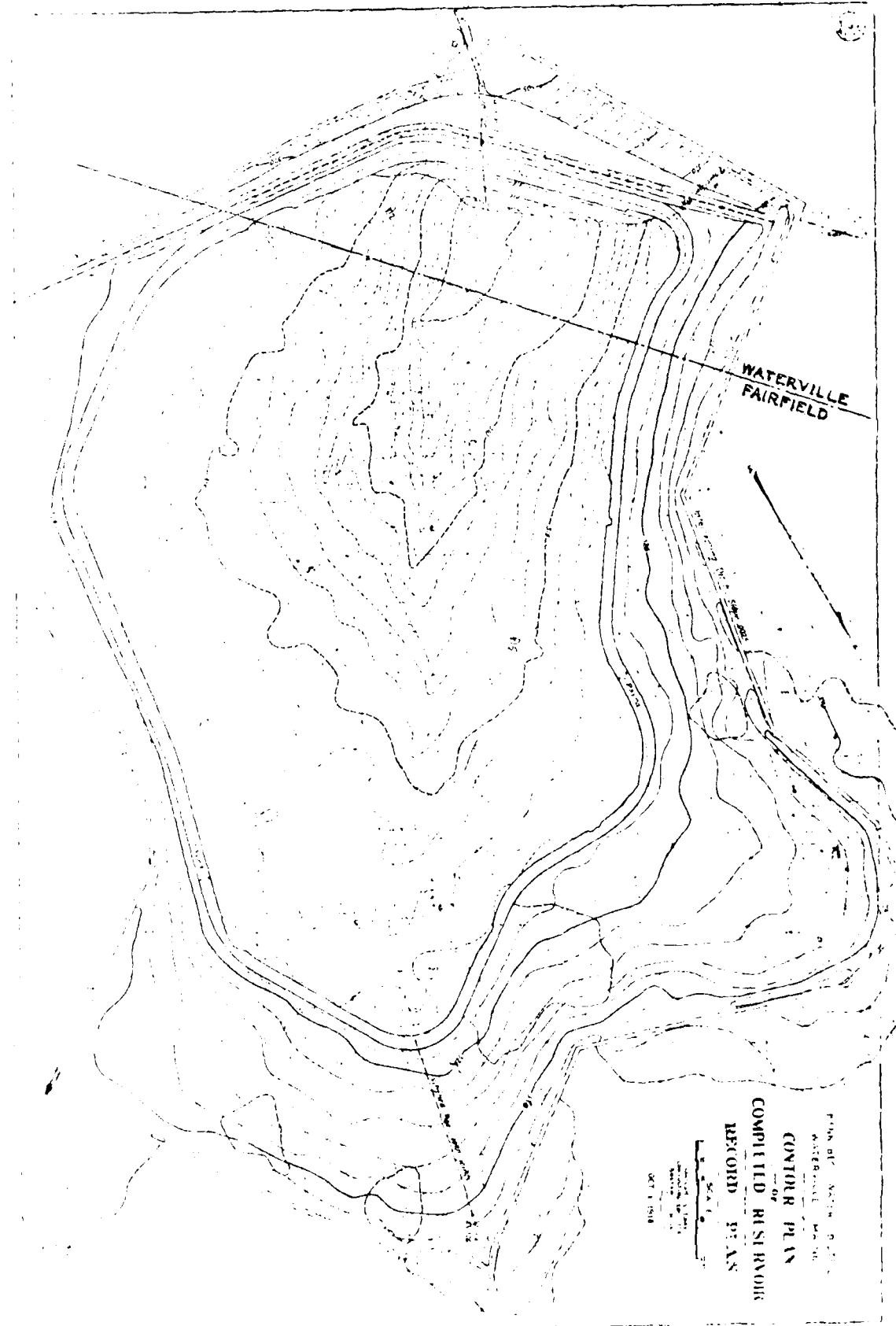
ENGINEERING DATA

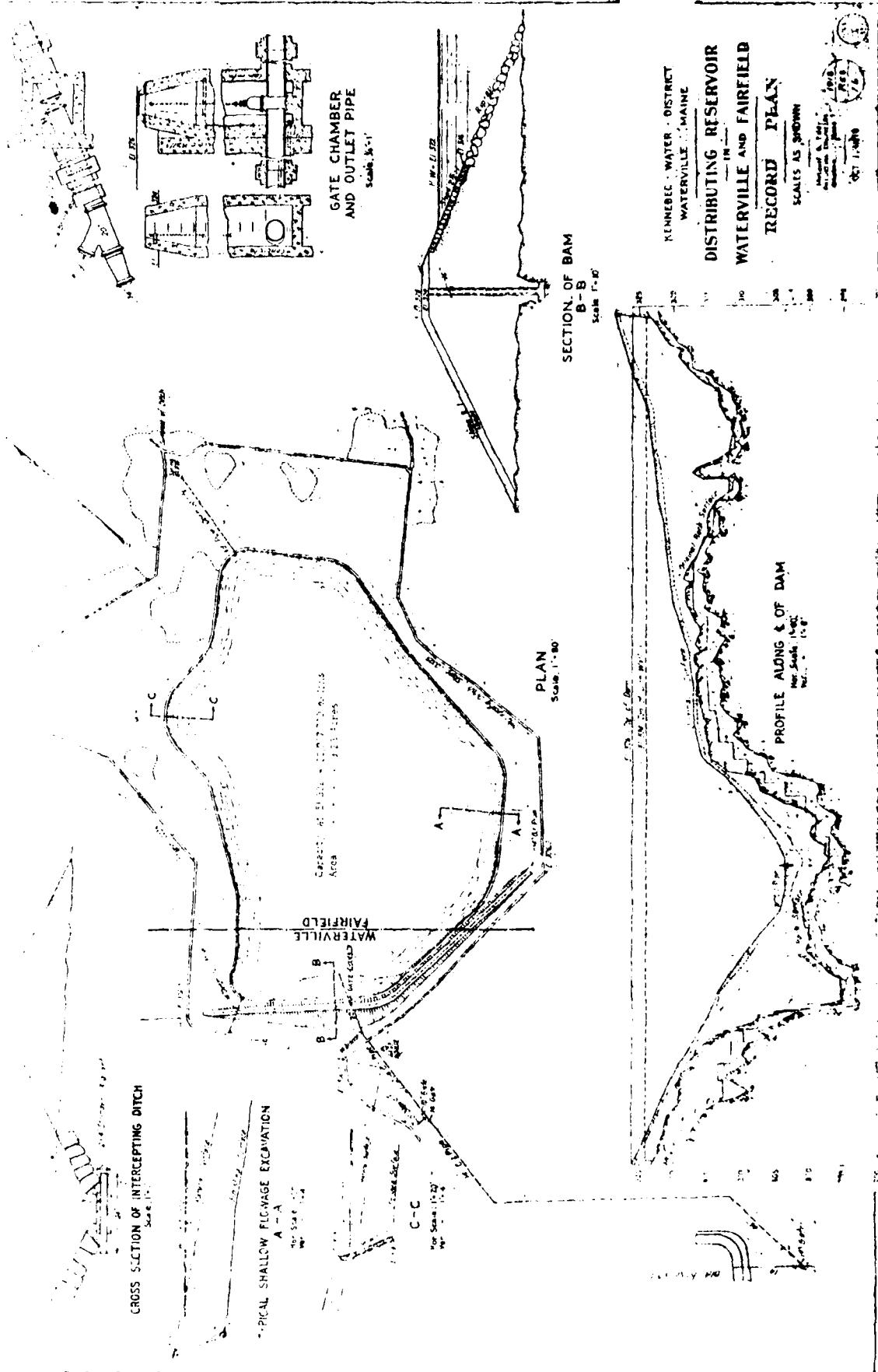
LIST OF ENCLOSED DRAWINGS

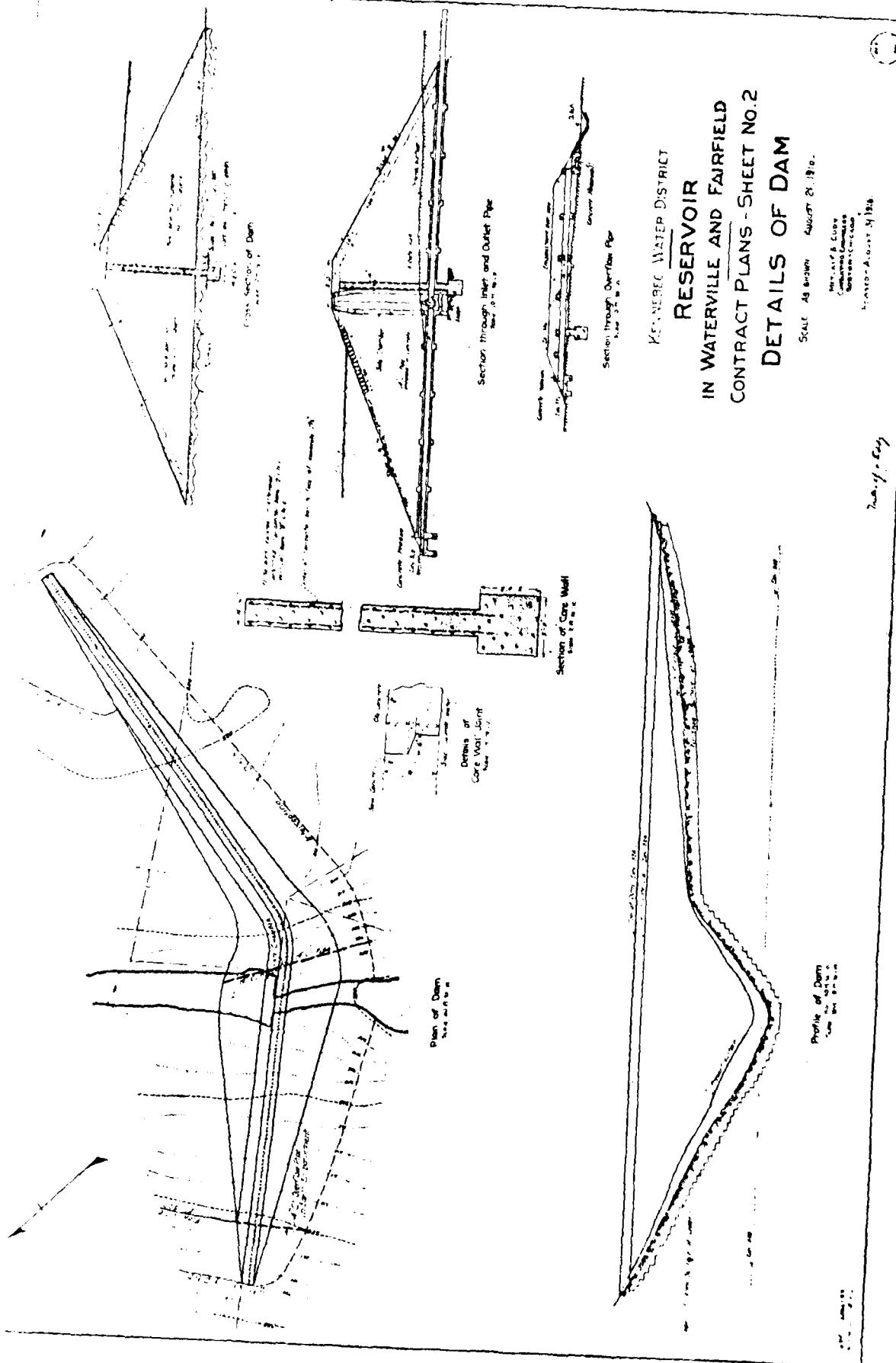
<u>PAGE</u>	<u>TITLE</u>
B-2	Plan for Relaying Paving at Reservoir of Kennebec Water District, July 1973. Improvements to Reservoir Dam, 1951
B-3	Reservoir Record Plan, Improvements Made 1951
B-4	Contour Plan of Completed Reservoir, Oct. 1, 1918
B-5	Record Plan, Oct. 1, 1918
B-6	Contract Plans - Sheet No. 2; Details of Dam, Aug. 21, 1916











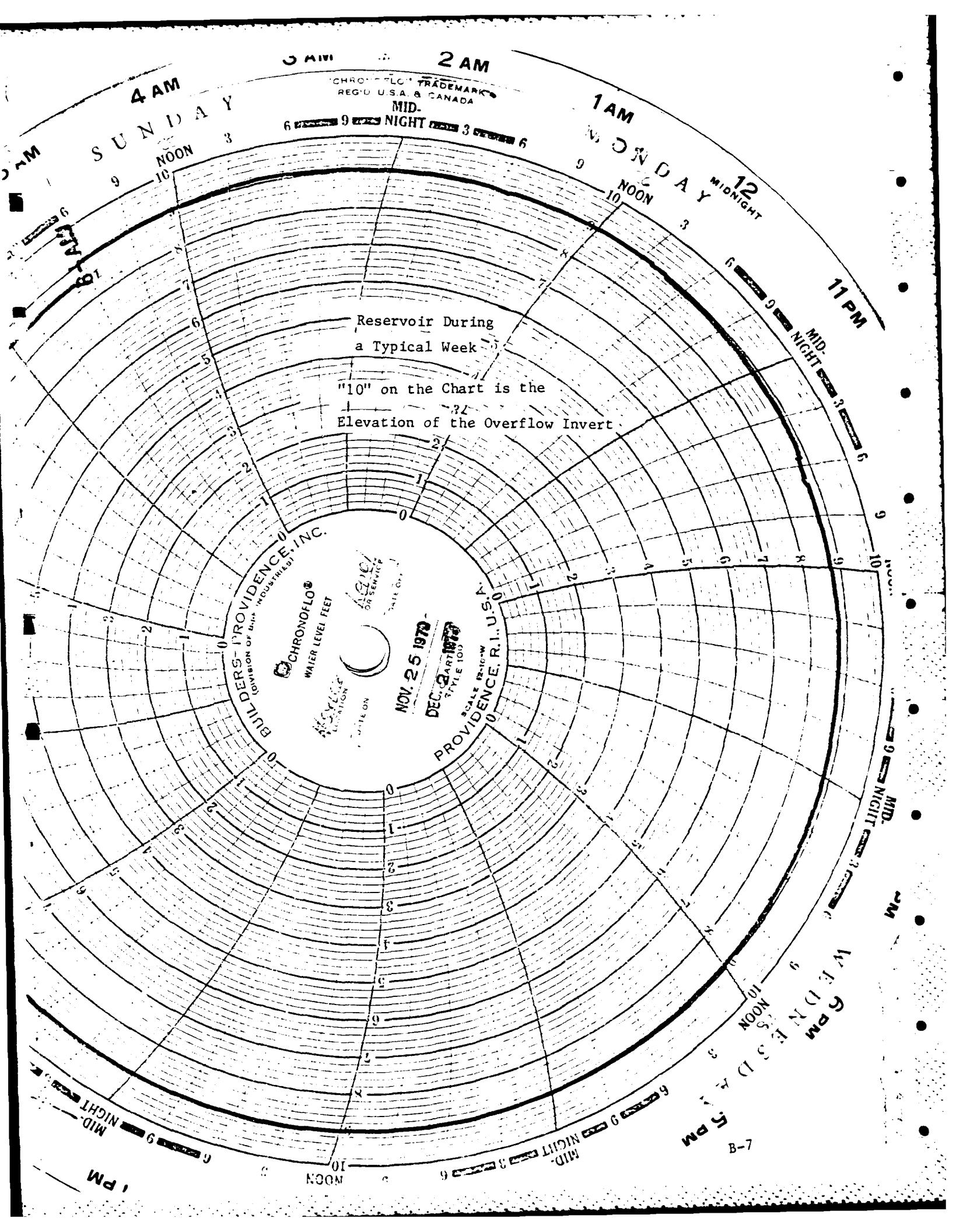
DETAILS OF DAM

Scale As Drawn

August 21, 1910.

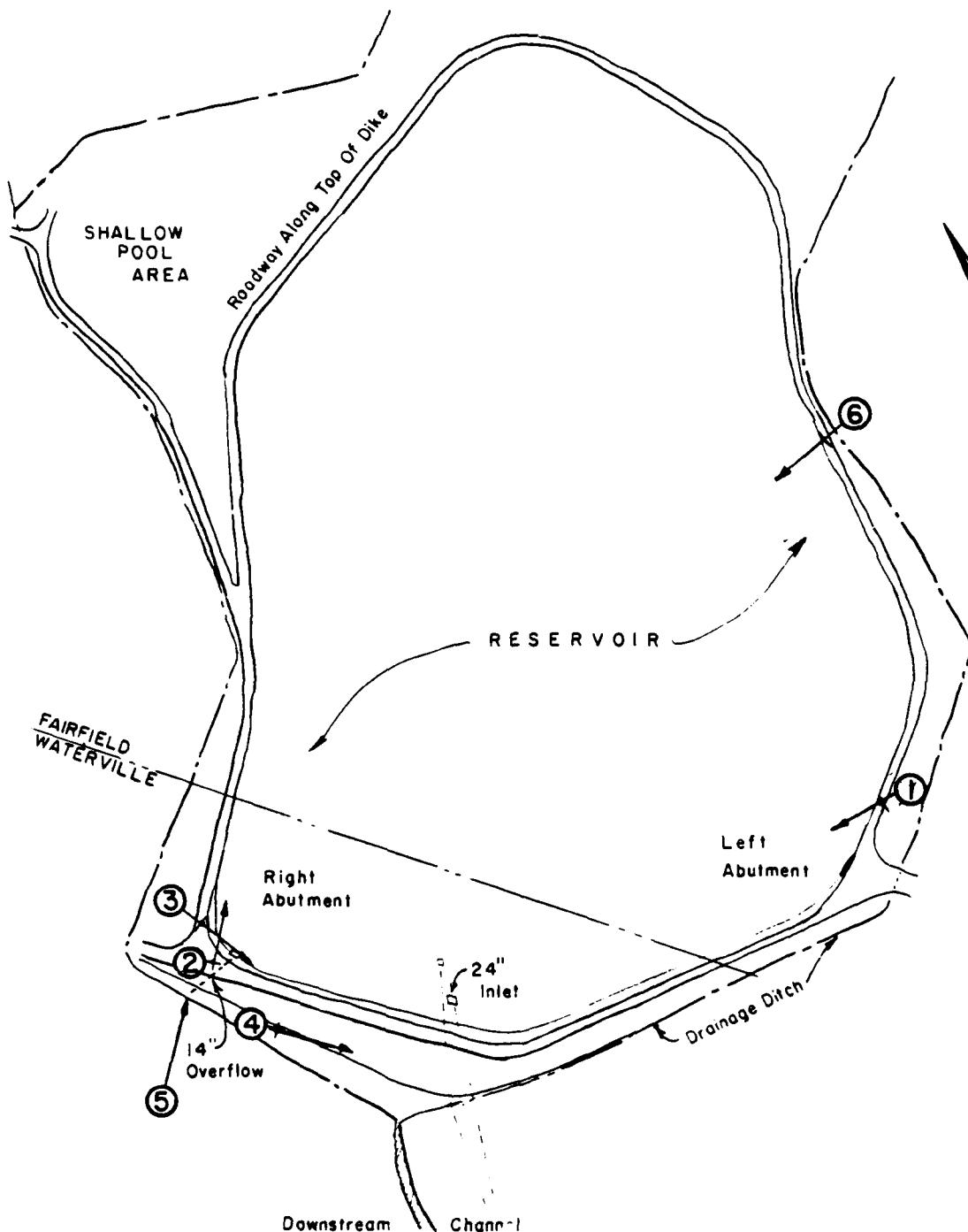
Kennebec Water District
Reservoir
In Waterville and Fairfield
Contract Plans - Sheet No. 2

Map of City



APPENDIX C

PHOTOGRAPHS



LEGEND

① PHOTO LOCATION

Not To Scale

**RESERVOIR DAM
PHOTO LOCATION**

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

MAIN

DATE SEPT. 1981

CLIENT 100 PLATE

1345-72



Photo 1
Upstream Face from
Left Abutment



Photo 2
Upstream Right
Abutment from
Overflow Structure



Photo 3
Upstream Right Face
with Concrete Over-
flow Structure

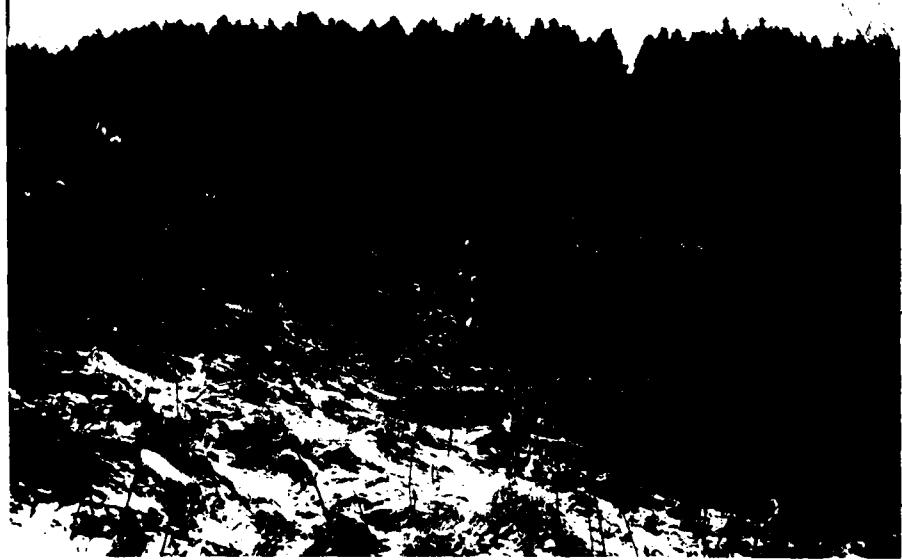


Photo 4
Downstream Face
from Right Side.

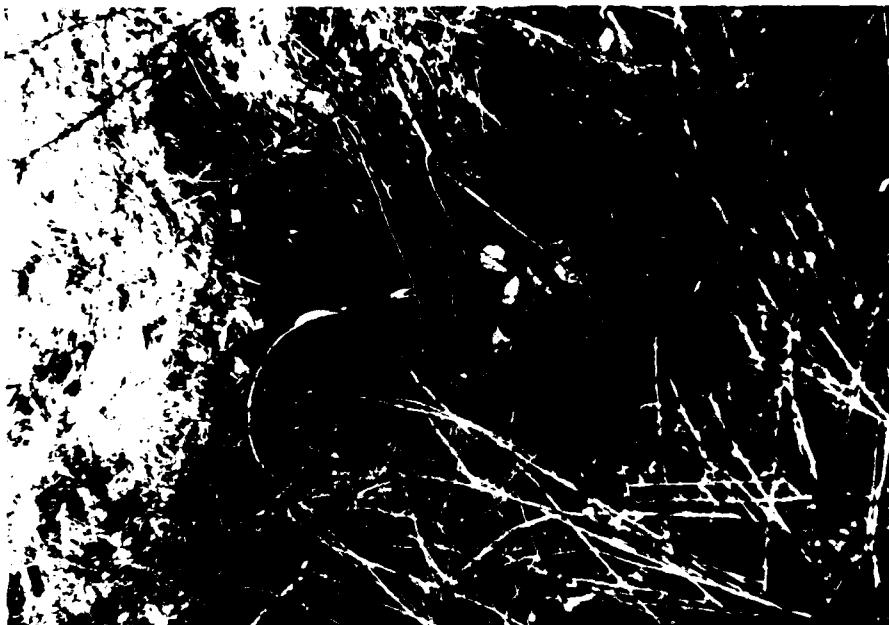


Photo 5
Downstream Outlet
of 14" Ø Overflow
Pipe

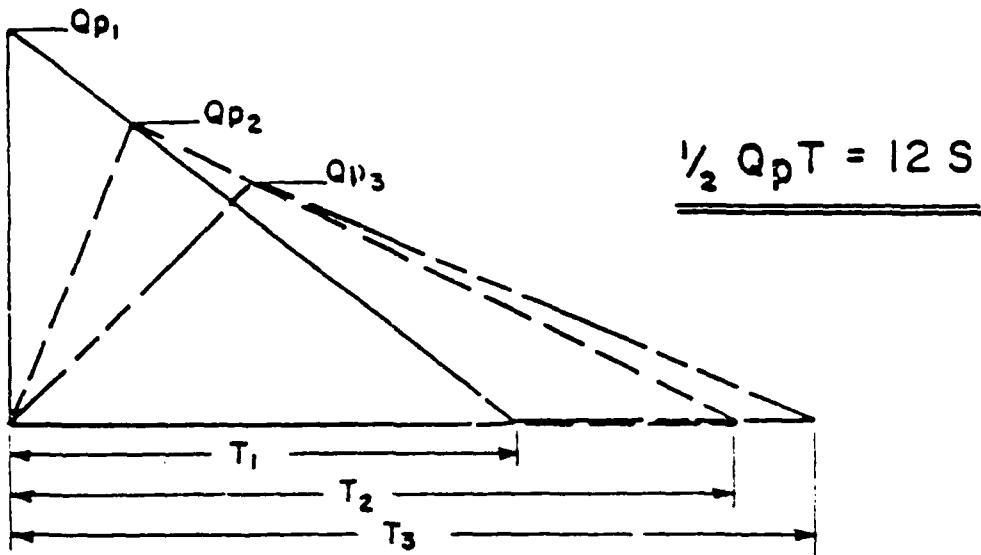


Photo 6
View Across Reservoir
from Left Side Looking
Towards Dam.

APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS



STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Q_{p1} = \frac{8}{27} w_b \sqrt{g} \gamma_0^{3/2}$$

w_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF CEM LENGTH ACROSS RIVER AT MID HEIGHT.

γ_0 = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOMPANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2} .

$$Q_{p2}(\text{TRIAL}) = Q_{p1} \left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2} .

$$Q_{p2} = Q_{p1} \left(1 - \frac{V_{\text{AVG}}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

SURCHARGE STORAGE ROUTING SUPPLEMENT

STEP 3: a. Determine Surcharge Height and
"STOR₂" To Pass "Q_{p2}"

b. Avg "STOR₁" and "STOR₂" and
Compute "Q_{p3}".

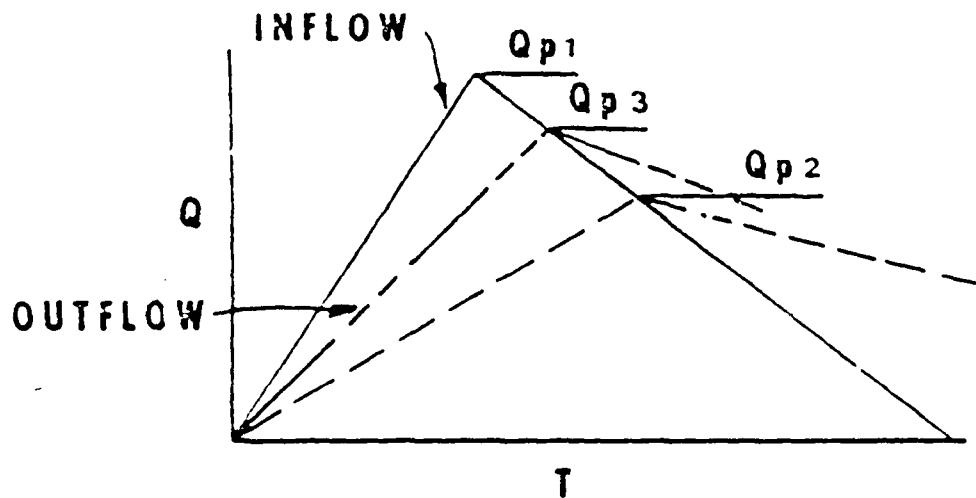
c. If Surcharge Height for Q_{p3} and
"STOR_{Avg}" agree O.K. If Not:

STEP 4: a. Determine Surcharge Height and
"STOR₃" To Pass "Q_{p3}"

b. Avg. "Old STOR_{Avg}" and "STOR₃"
and Compute "Q_{p4}"

c. Surcharge Height for Q_{p4} and
"New STOR_{Avg}" should Agree
closely

ESTIMATING EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES



STEP 1: Determine Peak Inflow (Q_{p1}) from Guide Curves.

STEP 2: a. Determine Surcharge Height To Pass " Q_{p1} ".

b. Determine Volume of Surcharge ($STOR_1$) In Inches of Runoff.

c. Maximum Probable Flood Runoff In New England equals Approx. 19", Therefore:

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR_1}{19}\right)$$

STEP 3: a. Determine Surcharge Height and " $STOR_2$ " To Pass " Q_{p2} "

b. Average " $STOR_1$ " and " $STOR_2$ " and Determine Average Surcharge and Resulting Peak Outflow " Q_{p3} ".

MAIN

Client GRG'S GE ENGINEERS
Subject KENNEBEC RESERVOIR
FLOOD ROUTING

Job No. 1245-V79 Sheet 1 of 33
By T. STOVR Date 4-29-80
Ckd. _____ Rev. _____

Drainage Area = 0.25 sq. mi.

For drainage area of 0.25 sq. mi. (by extending the Corps of Engineers Curve) $q_{p,0} = 2750 \text{ cfs / sq. mi.}$

The peak discharge becomes

$$q_p = 2750 \times 0.25 = 687.5 \text{ CFS.}$$

There is an intercepting ditch around the reservoir area preventing the flows to enter into the reservoir. In addition the dam is raised to top elevation 330.0 FT. and a dike of top elevation 328.0 FT was constructed around the circumference of the reservoir.

Due to this set-up no water is anticipated to enter into the reservoir except direct precipitation.

The PMP for this area is considered to be 19 inches which may raise the water elevation of the reservoir, about 1.6 ft. to elevation $327 + 1.6 = 328.6 \text{ FT}$ which will be lower than the crest elevation of the dam (330.0 FT).

The water surface elevation 328.6 FT is considered in dam break analyses. D-5

MAIN

Client CORPS OF ENGINEERS Job No. 1345-171 Sheet 2 of 33
Subject KENNEBEC RESERVOIR By T. STOVA Date 1-30-80
FLD 2 ROUTING Ckd. _____ Rev. _____

<u>ELV. (ft)</u>	<u>CAPACITY (GALLONS)</u>	<u>CAPACITY (AC-FT)</u>
304	14,000	0.043
305	51,000	0.157
306	121,000	0.371
307	237,000	0.727
308	407,000	1.249
309	639,000	1.961
310	953,000	2.925
311	1,369,000	4.902
312	1,409,000	5.859
313	2,605,000	7.995
314	3,494,000	10.723
315	4,632,000	14.216
316	6,082,000	18.666
317	7,973,000	24.470
318	10,421,000	31.983
319	13,217,000	40.564
320	16,107,000	49.434
321	22,000,000	67.520
323	25,200,000	77.341
324	29,200,000	89.618
325	33,400,000	102.508
326	37,300,000	114.477
327	40,000,000	122.764

MAIN

Client CARDS OF ENGINEERS

Job No. 1345-071 Sheet 3 of 33

Subject KENNEBEC RESERVOIR
FLOOD ROUTING

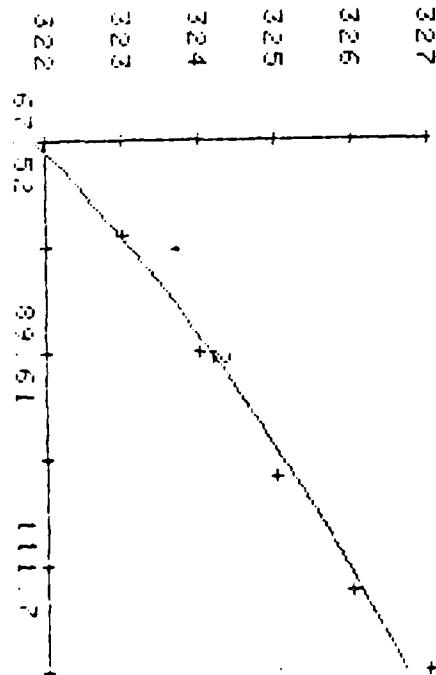
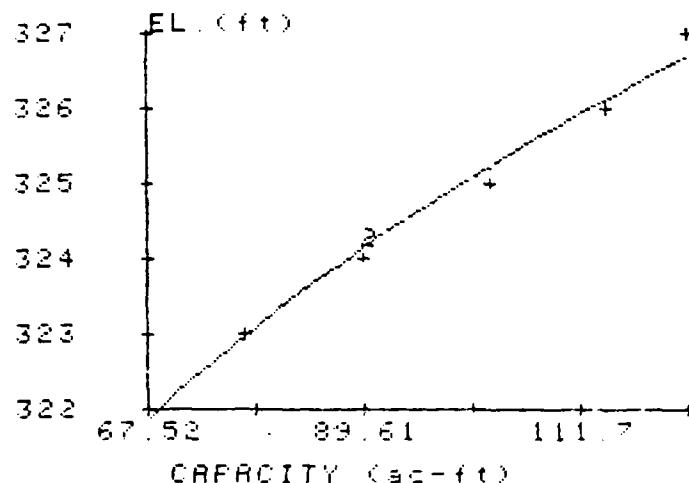
By T. OTOUA Date 4-30-80
Ckd. _____ Rev. _____

CURVE FITTING

X(I)	Y(I)
77.3410	323.0000
89.6180	324.0000
102.5080	325.0000
114.4770	326.0000
126.7640	327.0000
67.5200	322.0000

LABEL DELETED AT 78.5688
 LABEL DELETED AT 100.6664
 LABEL DELETED AT 122.7640
 ROW LOG PEG CODE 2
 SOURCE Cn 88 MS F
 TOTAL 17.6
 PEG 17.6 17.3 331.0
 PEGID 0.2 0.1
 R SOURCE = 0.988

$$YHAT = 367.992 + 8.042 \log X$$



Client CORPS OF ENGINEERS
 Subject KENNEBEC RESERVOIR
FLOOD ROUTING

Job No. 1345-072 Sheet 4 of 33
 By T. OTONA Date 6-5-80
 Chkd. _____ Rev. _____

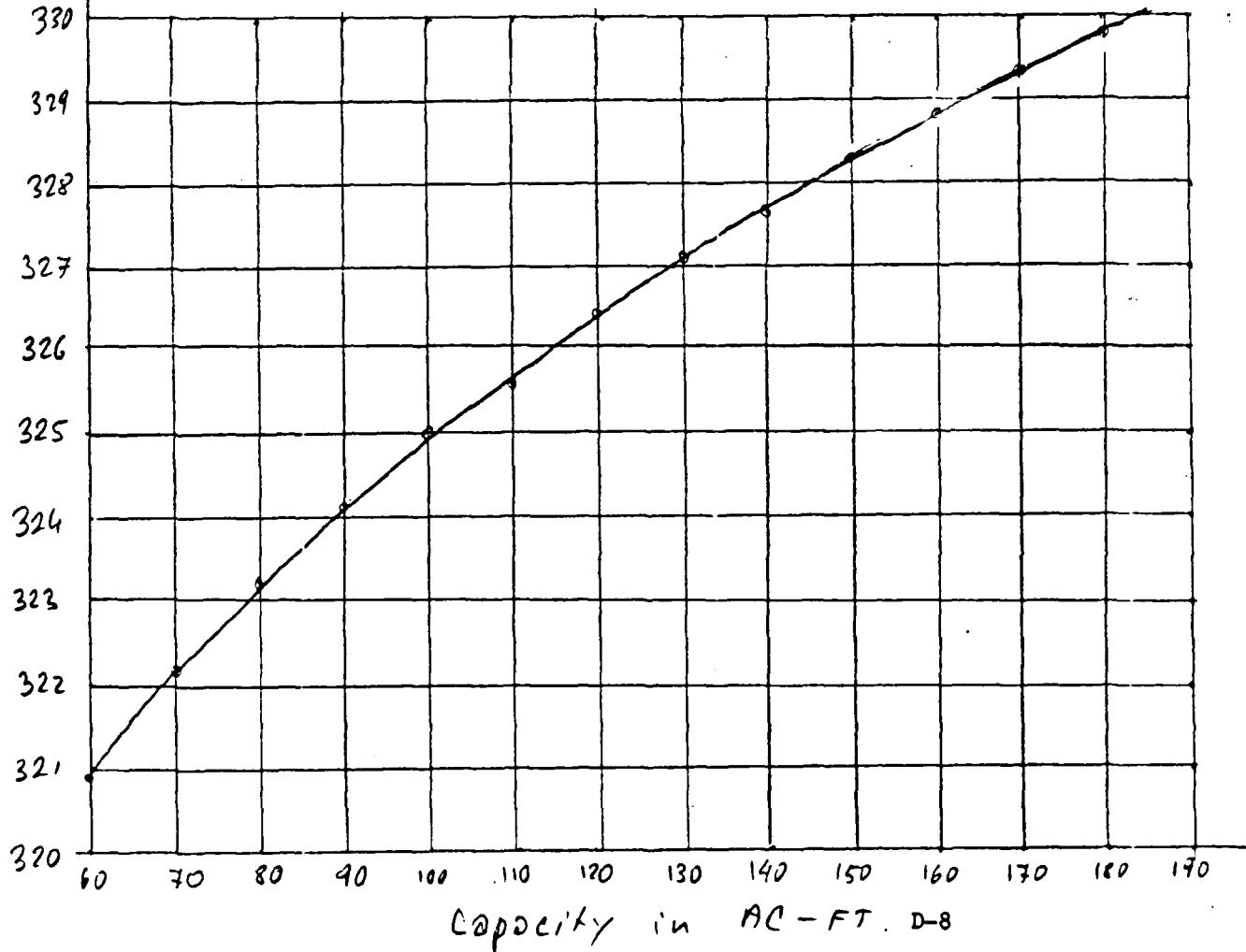
$$Y(EV) = 287.992 + 8.042 \log x(\text{capacity})$$

or,

$$x(\text{capacity}) = \exp \left[\frac{Y(EV) - 287.992}{8.042} \right]$$

Y in (ft), x in (ac-ft).

ELEV. - CAPACITY CURVE



STEP 1: Reservoir Storage at time of failure $W_R = 155.9 \text{ ALC-FT.}$
 $ELV = 328.6 \text{ FT.}$

STEP 2: The Failure outflow peak Q_{p_i} ,

$$Q_{p_i} = \frac{8}{27} W_b \sqrt{g} Y_0^{3/2} \quad (\text{Ref. Corps of Eng. Guideline})$$

Where,

W_b = Breach width : (ft.)

$$W_b = \frac{0.40}{0.35} W_d$$

W_d = Dam Length.

$$W_d = 0.40 \times 735 \text{ ft.} = 294.0 \text{ FT.}$$

Y_0 = Total Height from river bed to pool level
 at failure

$$Y_0 = 25.6 \text{ ft. } (328.6 - 303.0)$$

STEP 3: Derivation of Stage - Discharge Relationship

For simplification the cross-sections in any reach
 are converted as triangular shape.

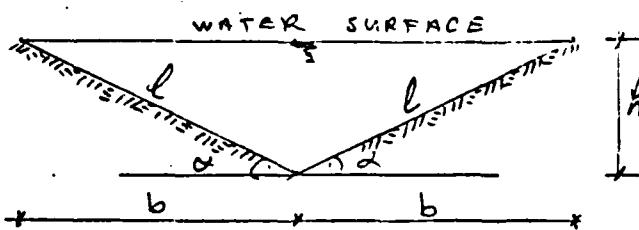
$$\text{Area, } A = \frac{h \times b}{2} \times 2$$

$$A = h \times b$$

$$\frac{h}{b} = \tan \alpha$$

$$b = \frac{h}{\tan \alpha}$$

$$A = \frac{h^2}{\tan \alpha} \quad \text{I}$$



Widted Parameter, W ,

$$W = 2\ell \quad \frac{b}{\ell} = \cos\alpha \quad \ell = \frac{b}{\cos\alpha}$$

$$W = 2 \frac{b}{\cos\alpha}$$

Hydraulic Radius, R ,

$$R = \frac{A}{W} = \frac{bh}{2 \frac{b}{\cos\alpha}} = \frac{h}{2} \cdot \cos\alpha$$

$$R^{2/3} = \left(\frac{h \cos\alpha}{2}\right)^{2/3}$$

Manning's Formula,

$$Q = \frac{1.49 A R^{2/3} S^{1/2}}{m}$$

$$Q = \frac{1.49}{m} \times \frac{h^2}{\tan\alpha} \times \left(\frac{h \cos\alpha}{2}\right)^{2/3} \times S^{1/2}$$

$$Q = \frac{1.49}{m} \times \frac{S^{1/2}}{\tan\alpha} \times \frac{(\cos\alpha)^{2/3}}{2^{2/3}} \times h^{8/3}$$

$$h = \left[\frac{m + \tan\alpha + 2^{2/3}}{1.49 + (\cos\alpha)^{2/3} \times S^{1/2}} \times Q \right]^{3/8}$$

$$h = \left[\frac{1.068 + m + \tan\alpha}{(\cos\alpha)^{2/3} \times S^{1/2}} \times Q \right]^{3/8}$$

S is slope
 n is roughness
 coefficient

THIS IS THE RATING
 FORMULA USED IN ALL
 REACHES

STEP 4: For this steps a computer program is developed
 which is presented in pages 8 through
 The results are tabulated in page 7.

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-6F2 Sheet 7 of 33

By T. OTTON Date 2-24-81

Chd. _____ Rev. _____

There is no emergency spillway and the only spillway is 14 inches overflow pipe at elev 327. Maximum water elev. during test flood is 328.6 and with 1.6 ft head the discharge from the pipe is assumed to be minimal for a study for pre failure conditions.

KENNEBEC DAM
DAM FAILURE ANALYSES

These calculations are performed according to the RULE OF THUMB procedures of the Corps of Engineers

The breach discharge:

$$Q_{bf} = 8.27 * W_b * e^{0.5} * Y_b^{3/2}$$

Where,

Y_b is the height of the breach (from river bed to the max. pool level)

W_b is 35% of the length of the dam, or $W_b = .35 * W_d$

e is the acceleration of the earth's gravity (32.2 ft/sec²)

$$Y_b = 25.6 \text{ (ft)}$$

$$W_d = 735 \text{ (ft)}$$

$$W_b = 257 \text{ (ft)}$$

From above equation,
 $Q_{bf} = 56023 \text{ (cfs)}$

The natural channel cross sections are simplified as triangular cross sections

The stage-discharge relationship becomes as:

$$h = [1.068 + n * \tan(a) * 0 * C \cos(a)^{2/3} / S^{1.5}]^{3/8} \dots (I)$$

Where,

Q = Discharge (cfs)

a = Side slope angle (deg)

S = Channel slope

The cross section Area:

$$A = h^2 * \tan(a) \dots (II)$$

The volume of the Reservoir:

$$V = \frac{1}{3} \pi r^2 h \text{ (cu-ft)}$$

$$\text{or, } V = 373,004 \text{ (cub-ft)}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-062 Sheet 2 of 33
 Subject KENNEBEC DAM By T. DIVVIA Date 2-24-81
FAILURE ANALYSIS Chd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V_1 \times M)$$

$$Q_{F2} = 46117 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 46117 \text{ (cfs)}$$

REACH (1) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} s &= 3.81 \text{ (deg.)} \\ S &= .04 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,
 $h = 15.1 \text{ (ft)}$

From Formula (II),

Total Area,

$$A = 3430 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 3430 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 1200727 \text{ (cub-ft.)}$$

$$h = 14 \text{ (ft)}$$

From Formula (II),

$$A = 2964 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2964 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 1037692 \text{ (cub-ft.)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 1119209 \text{ (cub-ft.)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} \times M)$$

$$Q_{F2} = 46730 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 14.1 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 14.1 (ft)

3.) Breach Discharge = 46730 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-UF2 Sheet 9 of 33
 By T. OTUVA Date 2-24-81

RevRev

$$Q_F2 = Q_F1 * (1 - V1 \times V)$$

$$Q_F2 = 39562 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_F2 + Q_t$$

$$Q = 39562 \text{ (cfs)}$$

$$h = 13 \text{ (ft)}$$

From Formula (II),

$$A = 2642 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2642 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 924975 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) \times \frac{1}{2}$$

$$V_{ave} = 986998 \text{ (cub-ft)}$$

$$Q_F2 = Q_F1 * (1 - V_{ave} \times V)$$

$$Q_F2 = 39989 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_F2 + Q_t$$

$$h_2 = 13.3 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 13.3 (ft)

3.) Breach Discharge = 39989 (cfs)

4.) Reach Length = 350 (ft)

R E A C H (2) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 3.81 \text{ (deg)} \\ S &= 0.4 \\ n &= 0.7 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft)}$$

$$Q = Q_F1 + Q_t$$

From Formula (I),

Total Height,

$$h = 14.1 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 2997 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2997 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 1049020 \text{ (cub-ft)}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-UF2 Sheet 10 of 33
Subject KENNEBEC DAM By T. DIVVIA Date 2-24-81
FAILURE ANALYSIS Ckd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V_1 / V)$$

$$Q_{P2} = 34498 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 34498 \text{ (cfs)}$$

$$h = 12 \text{ (ft)}$$

From Formula (II),

$$A = 2384 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2384 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 834682 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 883570 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} / V)$$

$$Q_{P2} = 34786 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 12.6 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 12.6 (ft)

3.) Breach Discharge = 34786 (cfs)

4.) Reach Length = 350 (ft)

REACH (3) CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$a = 3.81 \text{ (deg.)}$$

$$S = .04$$

$$n = .07$$

$$L = 350 \text{ (ft)}$$

From Formula (I),

Prefailure height:

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

Total Height,

$$h = 13.3 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 2664 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2664 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 932458 \text{ (cub-ft.)}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-OF2 Sheet 11 of 33
Subject KENNEBEC DAM by T. OTUVA Date 2-24-81
FAILURE ANALYSIS Ckd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V1 / V)$$

$$Q_{P2} = 30484 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 30484 \text{ (cfs)}$$

R E A C H < 4 > CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 3.81 \text{ (deg.)} \\ S &= .04 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

$$h = 12 \text{ (ft)}$$

From Formula (II),

$$A = 2173 \text{ (ft)}$$

Residual Area,

$$A2 = A - A1$$

$$A2 = 2173 \text{ (ft)}$$

From Formula (I),

$$V2 = A2 * L$$

Prefailure height,

$$V2 = 760721 \text{ (cub-ft)}$$

$$h1 = 0 \text{ (ft)}$$

$$V_{ave} = (V1 + V2) / 2$$

From Formula (II),

$$V_{ave} = 800311 \text{ (cub-ft)}$$

$$A1 = 0 \text{ (sq-ft.)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} / V)$$

$$Q_{P2} = 30687 \text{ (cfs)}$$

From Formula (I),

Total Height,

$$h = 12.6 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 2399 \text{ (sq-ft.)}$$

Residual Area,

From Formula (I),

$$A2 = A - A1$$

$$Q = Q_{P2} + Q_t$$

$$A2 = 2399 \text{ (sq-ft.)}$$

$$h2 = 12 \text{ (ft)}$$

Residual Volume,

RESULTS

$$V1 = L * A2$$

1.) Prefailure Height = 0 (ft)

$$V1 = 839901 \text{ (cub-ft)}$$

2.) Postfailure Height = 12 (ft)

3.) Breach Discharge = 30687 (cfs)

4.) Reach Length = 350 (ft)

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 12 of 33
 By T. OTUVA Date 2-24-87
 Chkd. Rev.

$$Q_{F2} = Q_{F1} * (1 - W_1 \times M)$$

$$Q_{F2} = 27232 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 27232 \text{ (cfs)}$$

REACH (5) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 3.81 \text{ (deg.)} \\ S &= .04 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 12 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 2184 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2184 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 764514 \text{ (cub-ft)}$$

$$h = 11 \text{ (ft)}$$

From Formula (II),

$$A = 1997 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1997 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 699009 \text{ (cub-ft)}$$

$$V_{ave} = (W_1 + V_2) / 2$$

$$V_{ave} = 731761 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} \times M)$$

$$Q_{F2} = 27380 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 11.5 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 11.5 (ft)

3.) Breach Discharge = 27380 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. J345-0E2 Sheet 13 of 33
By T. OTTOVA Date 2-24-81
Chkd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V_1 \times V)$$

$$Q_{P2} = 24550 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 24550 \text{ (cfs)}$$

P E A C H (6) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 3.81 \text{ (deg.)} \\ S &= .04 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

Total Height,

$$h = 11.5 \text{ (ft)}$$

From Formula (III),

Total Area,

$$A = 2005 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2005 \text{ (sq-ft)}$$

Residual Volume:

$$V_1 = L * A_2$$

$$V_1 = 701857 \text{ (cub-ft)}$$

$$h = 11 \text{ (ft)}$$

From Formula (II),

$$A = 1847 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1847 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 646718 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 674298 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} \times V)$$

$$Q_{P2} = 24661 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 11.1 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 11.1 (ft)

3.) Breach Discharge = 24661 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-052 Sheet 14 of 32
By T. OTTOVA Date 2-24-81

Chkd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V_1 \times U)$$

$$Q_{P2} = 22305 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 22305 \text{ (cfs)}$$

$$h = 10 \text{ (ft)}$$

From Formula (II),

$$A = 1719 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1719 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 601829 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 625371 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} \times U)$$

$$Q_{P2} = 22390 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 10.7 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 10.7 (ft)

3.) Breach Discharge = 22390 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-VF2 sheet 15 of 33
 By T. OTUVA Date 2-24-81
 Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - M) + M$$

$$Q_{F2} = 20400 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 20400 \text{ (cfs)}$$

R E A C H (8) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 3.81 \text{ (deg.)} \\ S &= .04 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 10.7 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1724 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1724 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 603558 \text{ (cub-ft)}$$

$$h = 10 \text{ (ft)}$$

From Formula (II),

$$A = 1608 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1608 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 562863 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 583210 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V)$$

$$Q_{F2} = 20467 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 10.3 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 10.3 (ft)

3.) Breach Discharge = 20467 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC RIVER
FAILURE ANALYSIS

Job No. 1345-0F2 Sheet 16 of 33
By T. OTTOVIA Date 2-24-81

Chkd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V1 \times V)$$

$$Q_{P2} = 18767 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 18767 \text{ (cfs)}$$

R E A C H (S) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$a = 3.81 \text{ (deg.)}$
 $S = .04$
 $n = .07$
 $L = 350 \text{ (ft)}$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

Total Height,

$$h = 10.3 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1612 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1612 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 564250 \text{ (cub-ft)}$$

$$h = 10 \text{ (ft)}$$

From Formula (II),

$$A = 1510 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1510 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 528710 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 546480 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} \times V)$$

$$Q_{P2} = 18820 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 10 \text{ (ft)}$$

RESULTS :

1) Prefailure Height = 0 (ft)

2) Postfailure Height = 10 (ft)

3) Breach Discharge = 18820 (cfs)

4) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-0F2 Sheet 17 of 33
By T. OTUVA Date 2-24-81

CKD. _____ Rev. _____

$$Q_F2 = Q_F1 * (1 - V1 * M)$$

$$Q_F2 = 15828 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_F2 + Q_F1$$

$$Q = 15828 \text{ (cfs)}$$

REACH (10) CALCULATIONS

Test flood discharge:
 $Q_F1 = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg)} \\ S &= .0133 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq. ft.)}$$

$$Q = Q_F1 + Q_F2$$

From Formula (I),

Total Height,

$$h = 7.8 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 3084 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 3084 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 1079542 \text{ (cub-ft)}$$

$$h = 7 \text{ (ft)}$$

From Formula (II),

$$A = 2708 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2708 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 948080 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 1013816 \text{ (cub-ft)}$$

$$Q_F2 = Q_F1 * (1 - V_{ave} * M)$$

$$Q_F2 = 16011 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_F2 + Q_F1$$

$$h_2 = 7.4 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 7.4 (ft)

3.) Breach Discharge = 16011 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-CF2 Sheet 18 of 33
By T. OTUVA Date 2-24-81
Chkd. Rev.

$$Q_{P2} = Q_{P1} * (1 - V_1 \times 0.5)$$

$$Q_{P2} = 13756 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 13756 \text{ (cfs)}$$

R E A C H (11) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= 0.133 \\ n &= 0.7 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

Total Height,

$$h = 7.4 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 2732 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2732 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 956261 \text{ (cub-ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 853380 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 904820 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} \times V)$$

$$Q_{P2} = 13877 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 7 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 7 (ft)

3.) Breach Discharge = 13877
(cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 19 of 33
By T. OTUVA Date 2-24-81
Chd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V1 \times V)$$

$$Q_{F2} = 12122 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 12122 \text{ (cfs)}$$

R E A C H (12) CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$s = 1.15 \text{ (deg.)}$$

$$S = .0133$$

$$n = .07$$

$$L = 350 \text{ (ft)}$$

$$h = 6 \text{ (ft)}$$

From Formula (II),

$$A = 2217 \text{ (ft)}$$

Residual Area,

$$A2 = A - A1$$

$$A2 = 2217 \text{ (ft)}$$

From Formula (I),

$$V2 = A2 * L$$

Prefailure height,

$$V2 = 776160 \text{ (cub-ft)}$$

$$h1 = 0 \text{ (ft)}$$

$$V_{ave} = (V1 + V2) / 2$$

From Formula (II),

$$V_{ave} = 817588 \text{ (cub-ft)}$$

$$A1 = 0 \text{ (sq-ft.)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} \times V)$$

$$Q_{F2} = 12207 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

Total Height,

$$h = 6.6 \text{ (ft)}$$

$$h = 7 \text{ (ft)}$$

From Formula (II),

From Formula (I),

Total Area,

$$Q = Q_{F2} + Q_t$$

$$A = 2454 \text{ (sq-ft.)}$$

$$h2 = 6.6 \text{ (ft)}$$

Residual Area,

RESULTS :

$$A2 = A - A1$$

$$A2 = 2454 \text{ (sq-ft.)}$$

Residual Volume,

$$1.) \text{ Prefailure Height} = 0 \text{ (ft)}$$

$$V1 = L * A2$$

$$2.) \text{ Postfailure Height} = 6.6 \text{ (ft)}$$

$$V1 = 859016 \text{ (cub-ft)}$$

$$3.) \text{ Breach Discharge} = 12207 \text{ (cfs)}$$

$$4.) \text{ Reach Length} = 350 \text{ (ft)}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-CF2 Sheet 20 of 33
Subject KENNEBEC DAM By T. OTTOVA Date 2-24-81
FAILURE ANALYSIS Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V1 / V2)$$

$$Q_{F2} = 10804 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 10804 \text{ (cfs)}$$

REACH (13) CALCULATIONS

$$h = 6 \text{ (ft)}$$

From Formula (II),

$$A = 2034 \text{ (ft)}$$

Residual Area,

$$A2 = A - A1$$

$$A2 = 2034 \text{ (ft)}$$

From Formula (I),

$$V2 = A2 * L$$

Prefailure height,

$$V2 = 711976 \text{ (cub-ft)}$$

$$h1 = 0 \text{ (ft)}$$

$$V_{ave} = (V1 + V2) / 2$$

From Formula (III),

$$V_{ave} = 746099 \text{ (cub-ft)}$$

$$A1 = 0 \text{ (sq-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V2)$$

From Formula (I),

$$Q_{F2} = 10865 \text{ (cfs)}$$

Total Height,

From Formula (I),

$$h = 6.6 \text{ (ft)}$$

From Formula (II),

Prefailure Height = 0 (ft)

Total Area,

$$A = 2229 \text{ (sq-ft)}$$

A = 2229 (sq-ft)

Residual Area,

$$A2 = A - A1$$

$$A2 = 2229 \text{ (sq-ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 6.4 (ft)

D-24 3.) Breach Discharge = 10865 (cfs)

4.) Reach Length = 350 (ft)

Residual Volume,

$$V1 = L * A2$$

$$V1 = 780221 \text{ (cub-ft)}$$

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 21 of 33
 By T. OTTOVA Date 2-24-81
 Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V_1 \times V)$$

$$Q_{F2} = 9721 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 9721 \text{ (cfs)}$$

REACH (14) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= 0.133 \\ n &= 0.7 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq. ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 6.4 \text{ (ft)}$$

From Formula (III),

Total Area,

$$A = 2042 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 2042 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 715006 \text{ (cub-ft)}$$

$$h = 6 \text{ (ft)}$$

From Formula (II),

$$A = 1879 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1879 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 657767 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 686386 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} \times V)$$

$$Q_{F2} = 9767 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 6.1 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 6.1 (ft)

D-25 3.) Breach Discharge = 9767 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-0F2 Sheet 22 of 32
By T. OTUVA Date 2-24-81
Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V1 \times 0)$$

$$Q_{F2} = 8818 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 8818 \text{ (cfs)}$$

R E A C H (15) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg)} \\ S &= 0.133 \\ n &= 0.7 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq ft)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,
 $h = 6.1 \text{ (ft)}$

From Formula (II),

Total Area,

$$A = 1885 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1885 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 660089 \text{ (cub-ft)}$$

$$h = 5 \text{ (ft)}$$

From Formula (II),

$$A = 1746 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1746 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 611359 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 635724 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} \times 0)$$

$$Q_{F2} = 8853 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 5.9 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 5.9 (ft)

3.) Breach Discharge = 8853 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-OF2 Sheet 23 of 33
 By T. OTTOVA Date 2-24-81

Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - \pi)$$

$$Q_{F2} = 8053 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 8053 \text{ (cfs)}$$

R E F O C H (16) CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$a = 1.15 \text{ (deg)}$$

$$S = 0.33$$

$$n = 0.7$$

$$L = 350 \text{ (ft)}$$

$$h = 5 \text{ (ft)}$$

From Formula (II),

$$A = 1631 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1631 \text{ (ft)}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 5.9 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1751 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1751 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 613180 \text{ (cub-ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 571160 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 592174 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V)$$

$$Q_{F2} = 8081 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 5.7 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 5.7 (ft)

3.) Breach Discharge = 8081 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 24 of 33
 By T. OTIVIA Date 2-24-81
 Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V_1 * \eta_1)$$

$$Q_{F2} = 7399 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 7399 \text{ (cfs)}$$

$$h = 5 \text{ (ft)}$$

From Formula (II),

$$A = 1531 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1531 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 536015 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 554320 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} * \eta_1)$$

$$Q_{F2} = 7421 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 5.5 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 8 (ft)

2.) Postfailure Height = 5.5 (ft)

3.) Breach Discharge = 7421 (cfs)

4.) Reach Length = 350 (ft)

R E A C H (17) CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$s = 1.15 \text{ (deg.)}$$

$$\eta = 0.33$$

$$r = 0.7$$

$$L = 350 \text{ (ft)}$$

From Formula (I),

Prefailure height,

$$h_1 = 8 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 5.7 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1636 \text{ (sq-ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1636 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 572624 \text{ (cub-ft)}$$

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC RIVER
FAILURE ANALYSIS

Job No. J345-OF2 Sheet 25 of 33
By T. OTTOVA Date 2-24-81
Chkd. Rev.

$$Q_{P2} = Q_{P1} * (1 - V1)$$

$$Q_{P2} = 6834 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 6834 \text{ (cfs)}$$

$$h = 5 \text{ (ft)}$$

From Formula (II),

$$A = 1442 \text{ (ft)}$$

Residual Area,

$$A2 = A - A1$$

$$A2 = 1442 \text{ (ft)}$$

$$V2 = A2 * L$$

$$V2 = 505001 \text{ (cub-ft)}$$

$$V_{ave} = (V1 + V2) / 2$$

$$V_{ave} = 521100 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} * W)$$

$$Q_{P2} = 6852 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h2 = 5.3 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 5.3 (ft)

D-29 3.) Breach Discharge = 6852 (cfs)

4.) Reach Length = 350 (ft)

REACH (18') CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= .0133 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h1 = 0 \text{ (ft)}$$

From Formula (II),

$$A1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

$$\begin{aligned} \text{Total Height,} \\ h &= 5.5 \text{ (ft)} \end{aligned}$$

From Formula (II),

$$\begin{aligned} \text{Total Area,} \\ A &= 1534 \text{ (sq-ft)} \end{aligned}$$

Residual Area,

$$\begin{aligned} A2 &= A - A1 \\ A2 &= 1534 \text{ (sq-ft)} \end{aligned}$$

Residual Volume,

$$V1 = L * A2$$

$$V1 = 537196 \text{ (cub-ft)}$$

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-0F2 Sheet 26 of 33
 By T. OTTOVIA Date 2-24-81

Chkd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V1 \times V)$$

$$Q_{P2} = 6341 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 6341 \text{ (cfs)}$$

R E A C H (19) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= 0133 \\ n &= .07 \\ L &= 350 \text{ (ft.)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft.)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

Total Height,
 $h = 5.3 \text{ (ft.)}$

From Formula (II),
 Total Area,

$$A = 1445 \text{ (sq-ft.)}$$

Residual Area,

$$\begin{aligned} A_2 &= A - A_1 \\ A_2 &= 1445 \text{ (sq-ft.)} \end{aligned}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 505976 \text{ (cub-ft.)}$$

$$h = 5 \text{ (ft.)}$$

From Formula (II),

$$A = 1364 \text{ (ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1364 \text{ (ft.)}$$

$$V_2 = A_2 * L$$

$$V_2 = 477430 \text{ (cub-ft.)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 491703 \text{ (cub-ft.)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} \times C)$$

$$Q_{P2} = 6355 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 5.2 \text{ (ft.)}$$

RESULTS

1) Prefailure Height = 0 (ft.)

2) Postfailure Height = 5.2 (ft.)

3) Breach Discharge = 6355 (cfs)

4) Reach Length = 350 (ft.)

MAIN

Client CORPS OF ENGINEERS
Subject KENNEBEC DBM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 27 of 33
By T. OTTOVA Date 2-24-81
Chkd. _____ Rev. _____

$$Q_{P2} = Q_{P1} * (1 - V_1 / V)$$

$$Q_{P2} = 5908 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 5908 \text{ (cfs)}$$

REACH (20') CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$a = 1.15 \text{ (deg.)}$$

$$S = 0.0133$$

$$n = 0.7$$

$$L = 350 \text{ (ft)}$$

$$h = 5 \text{ (ft)}$$

From Formula (II),

$$A = 1293 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1293 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 452754 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 465498 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} / V)$$

$$Q_{P2} = 5920 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 5 \text{ (ft)}$$

RESULTS

- 1.) Prefailure Height = 0 (ft)
- 2.) Postfailure Height = 5 (ft)
- 3.) Breach Discharge = 5920 (cfs)
- 4.) Reach Length = 350 (ft)

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-012 Sheet 28 of 33
 By T. OTTOVIA Date 2-24-81
 Chkd. _____ Rev. _____

$$Q_{F2} = Q_{F1} + Q_t = V_1 \times 0.9$$

$$Q_{F2} = 5525 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 5525 \text{ (cfs)}$$

REACH (21) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= .0133 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 5 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1295 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1295 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 453440 \text{ (cub-ft.)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1230 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1230 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 430537 \text{ (cub-ft.)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 441988 \text{ (cub-ft.)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V)$$

$$Q_{F2} = 5534 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 4.9 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 4.9 (ft)

3.) Breach Discharge = 5534 (cfs)

4.) Reach Length = 350 (ft)

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-0F2 Sheet 29 of 33
 By T. OTTOVA Date 2-24-81
 Chkd. Rev.

$$Q_{P2} = Q_{P1} * (1 - V1)$$

$$Q_{P2} = 5183 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$Q = 5183 \text{ (cfs)}$$

REACH (22) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1.15 \text{ (deg.)} \\ S &= .0133 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{P1} + Q_t$$

From Formula (I),

$$\begin{aligned} \text{Total Height,} \\ h &= 4.9 \text{ (ft)} \end{aligned}$$

From Formula (II),

$$\begin{aligned} \text{Total Area,} \\ A &= 1231 \text{ (sq-ft)} \end{aligned}$$

Residual Area,

$$\begin{aligned} A_2 &= A - A_1 \\ A_2 &= 1231 \text{ (sq-ft)} \end{aligned}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 431120 \text{ (cub-ft)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1172 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1172 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 410426 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 420773 \text{ (cub-ft)}$$

$$Q_{P2} = Q_{P1} * (1 - V_{ave} / V)$$

$$Q_{P2} = 5192 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{P2} + Q_t$$

$$h_2 = 4.8 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 4.8 (ft)

3.) Breach Discharge = 5192 (cfs)

4.) Reach Length = 350 (ft)

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-062 Sheet 30 of 33

By T. OTUVA Date 2-24-81

Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - 41 \times 3)$$

$$Q_{F2} = 4829 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 4829 \text{ (cfs)}$$

REACH (23) CALCULATIONS

Test flood discharge:
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1 \text{ (deg.)} \\ \theta &= .01 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 4.8 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1353 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1353 \text{ (sq-ft.)}$$

Residual Volume:

$$V_1 = L * A_2$$

$$V_1 = 473561 \text{ (cub-ft.)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1281 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1281 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 448571 \text{ (cub-ft.)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 461066 \text{ (cub-ft.)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V_1)$$

$$Q_{F2} = 4839 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 4.7 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 4.7 (ft)

3.) Breach Discharge = 4839 (cfs)

4.) Reach Length = 350 (ft)

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-0-2 Sheet 31 of 33
 By T. OTUVA Date 2-24-81
 Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - M_1) + Q_t$$

$$Q_{F2} = 4519 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 4519 \text{ (cfs)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1219 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1219 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 426759 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 437998 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} * D)$$

$$Q_{F2} = 4527 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 4.6 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 8 ft

2.) Postfailure Height = 4.6 ft

3.) Breach Discharge = 4527 cfs

4.) Breach Length = 350 ft

FEA C.H. (24) CALCULATIONS

Test flood discharge
 $Q_t = 0 \text{ (cfs)}$

$$\begin{aligned} s &= 1 \text{ (deg.)} \\ S &= 0.1 \\ n &= 0.7 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 8 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 4.7 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1263 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1263 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 449237 \text{ (cub-ft.)}$$

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-062 Sheet 32 of 33

By T. OTTOVA Date 2-24-81

Chkd. _____ Rev. _____

$$Q_{F2} = Q_{F1} + (1 - W_1) \times Q_1$$

$$Q_{F2} = 4242 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_1$$

$$Q = 4242 \text{ (cfs)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1162 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1162 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 406996 \text{ (cub-ft)}$$

$$W_{av} = (W_1 + V_2) \times 2$$

$$W_{av} = 417161 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - W_{av} \times 0.5)$$

$$Q_{F2} = 4249 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_1$$

$$h_2 = 4.5 \text{ (ft)}$$

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 4.5 (ft)

3.) Breach Discharge = 4249 (cfs)

4.) Breach Length = 350 (ft)

R E A C H < 25 > CALCULATIONS

Test flood discharge:
 $Q_1 = 0 \text{ (cfs)}$

$$\begin{aligned} a &= 1 \text{ (deg)} \\ G &= .01 \\ n &= .07 \\ L &= 350 \text{ (ft)} \end{aligned}$$

From Formula (I),

Prefailure height,

$$h_1 = 0 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq.ft.)}$$

$$Q = Q_{F1} + Q_1$$

From Formula (I),

Total Height,
 $h = 4.6 \text{ (ft)}$

From Formula (II),

Total Area,

$$A = 1220 \text{ (sq-ft)}$$

Residual Area,

$$P_2 = Q - A_1$$

$$A_2 = 1220 \text{ (sq-ft)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 427326 \text{ (cub-ft)}$$

MAIN

Client CORPS OF ENGINEERS
 Subject KENNEBEC DAM
FAILURE ANALYSIS

Job No. 1345-072 Sheet 33 of 33
 By T. OTUVA Date 2-24-81

Ckd. _____ Rev. _____

$$Q_{F2} = Q_{F1} * (1 - V1 * M)$$

$$Q_{F2} = 3994 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$Q = 3994 \text{ (cfs)}$$

$$h = 4 \text{ (ft)}$$

From Formula (II),

$$A = 1111 \text{ (ft)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1111 \text{ (ft)}$$

$$V_2 = A_2 * L$$

$$V_2 = 369004 \text{ (cub-ft)}$$

$$V_{ave} = (V_1 + V_2) / 2$$

$$V_{ave} = 398244 \text{ (cub-ft)}$$

$$Q_{F2} = Q_{F1} * (1 - V_{ave} / V_1)$$

$$Q_{F2} = 4000 \text{ (cfs)}$$

From Formula (I),

$$Q = Q_{F2} + Q_t$$

$$h_2 = 4.4 \text{ (ft)}$$

RESULTS

1.) Prefailure Height = 6 (ft)

2.) Postfailure Height = 4.4 (ft)

3.) Breach Discharge = 4000 (cfs)

4.) Reach Length = 350 (ft)

SEARCH (26) CALCULATIONS

Test flood discharge:

$$Q_t = 0 \text{ (cfs)}$$

$$a = 1 \text{ (deg.)}$$

$$S = .01$$

$$n = .07$$

$$L = 350 \text{ (ft)}$$

From Formula (I),

Prefailure height,

$$h_1 = 6 \text{ (ft)}$$

From Formula (II),

$$A_1 = 0 \text{ (sq-ft.)}$$

$$Q = Q_{F1} + Q_t$$

From Formula (I),

Total Height,

$$h = 4.5 \text{ (ft)}$$

From Formula (II),

Total Area,

$$A = 1164 \text{ (sq-ft.)}$$

Residual Area,

$$A_2 = A - A_1$$

$$A_2 = 1164 \text{ (sq-ft.)}$$

Residual Volume,

$$V_1 = L * A_2$$

$$V_1 = 407483 \text{ (cub-ft.)}$$

APPENDIX E

INVENTORY SHEETS

PART I - INVENTORY OF DAMS IN THE UNITED STATES

PURSUANT TO PUBLIC LAW 92-502

Some minor side features

PART I - INVENTORY OF DAMS IN THE UNITED STATES <i>(PURSUANT TO PUBLIC LAW 92-167)</i>											
<i>See reverse side for instructions</i>											
[2] [3] [4]			[5] [6] [7]			[8]			[9]		
[10]			[11]			[12]			[13]		
IDENTIFICATION NE DME 011 01	NAME RESERVOIR DAM										
	STATE NE	DIVISION 9	COUNTY 10	COUNTY GROUP 11	COUNTY 12	COUNTY 13	COUNTY 14	COUNTY 15	COUNTY 16	COUNTY 17	COUNTY 18
FORM APPROVED OMB NO. 49-RO421											
REQUIREMENTS CONTROL SYMBOL DAEN-CWE-17											
IDENTITY NUMBER NE 00472											
STATE 1 2 3 4 5 6 7											
REPORT DATE DAY MO YR											
LATITUDE (N. or S.) ° ° ° ° ° °											
LONGITUDE (W. or E.) ° ° ° ° ° °											

IDENTIFICATION (Continued)	POPULAR NAME	NAME OF IMPOUNDMENT	
		1	2
69	10	1	1
12	1	2	1
13	1	3	1
14	1	4	1
15	1	5	1
16	1	6	1
17	1	7	1
18	1	8	1
19	2	1	1
20	2	2	1
21	2	3	1
22	2	4	1
23	2	5	1
24	2	6	1
25	2	7	1
26	2	8	1
27	2	9	1
28	2	10	1
29	3	1	1
30	3	2	1
31	3	3	1
32	3	4	1
33	3	5	1
34	3	6	1
35	3	7	1
36	3	8	1
37	3	9	1
38	3	10	1
39	4	1	1
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54	5	6	1
55	5	7	1
56	5	8	1
57	5	9	1
58	5	10	1
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63	6	5	1
64	6	6	1
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66	6	8	1
67	6	9	1
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87	8	9	1
88	8	10	1
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101	10	3	1
102	10	4	1
103	10	5	1
104	10	6	1
105	10	7	1
106	10	8	1
107	10	9	1
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110	11	2	1
111	11	3	1
112	11	4	1
113	11	5	1
114	11	6	1
115	11	7	1
116	11	8	1
117	11	9	1
118	11	10	1
119	12	1	1
120	12	2	1
121	12	3	1
122	12	4	1
123	12	5	1
124	12	6	1
125	12	7	1
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391	39	3	1
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393	39	5	1
394	39	6	1
395	39	7	1
396	39	8	1
397	39	9	1
398	39	10	1
399	40	1	1
400	40	2	1
401	40	3	1
402	40		

REGD	LOCATION	BASIN	RIVER OR STREAM												NEAREST DOWNSTREAM CITY - TOWN - VILLAGE												DIST FROM DAM (mi)	POPULATION																																																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
6 9 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80									
6 1 0 3	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80					

GENERAL INSTRUCTIONS

This form is for use in preparing the inventory of dams in the United States under the requirements of the National Program for the Inspection of Dams, P.L. 92-367. All items of Part I and Part II (Lines 0-9) must be completed as instructed below. Print entries **glossily** in ink or pencil. For letters o, e, and i, write **Q, Z, and I**.

Write only one letter or numeral in each space. Do not use more letters than blocks allowed for an item. Do not abbreviate on **four** all letter codes or word entries place **first letters in left block of field**. In word fields **any** alphabetic, numeric or special character may be entered. For all numerical entries, use only numerals placing the last digit of number in the right block of field, including trailing zeros. Do not include a decimal point! In fields where decimals are required values are to be placed around the decimal point printed on the form.

Leave blank those spaces where item does not apply, e.g., do not write "N/A", " ", "None", etc., unless instructed to do so by specific instructions. Use the remarks line when additional space is needed for an item, or to clarify an entry. Preface each remark with the item number (See Item 1b8 or 1b9 Instructions)

PART I

ITEM 1. DIVISION Enter the three (3) letter office symbol for the division making the report in accordance with ABBR Report Code, Appendix B, F.R. 18-2.1, Civil Works Information System, e.g., NAD, ORD, SWD, etc.

ITEM 2. COUNTY Enter three (3) digit county identification in accordance with FIPS PUB 6-1

ITEM 3. CONG. DIST. Enter one (1) or two (2) digit number for congressional districts in which dam is located.

ITEM 4. CITY Enter the three (3) letter principal state abbreviation in accordance with FIPS PUB 6-1

ITEM 5. STATE Enter the three (3) letter state abbreviation plus "00 NAME" plus a sequential number. Example: If two dams in the State of Alabama do not have names, they would be named as AL00NAME1 and AL00NAME2.

ITEM 6. LATITUDE AND LONGITUDE Enter the latitude and longitude in degrees, minutes and tenths of a minute. All geographical locations items pertain to dam 26's maximum section.

ITEM 7. REPORT DATE Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year (e.g., 12/12/1974) in which the data has been revised, updated or otherwise changed.

ITEM 8. POPULAR NAME OF DAM Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year (e.g., 12/12/1974) in which the official name of the dam in common use. Enter the name in this space leave blank if not applicable.

ITEM 9. NAME OF INSTITUTION Enter official name of lake or reservoir. Leave blank if reservoir does not have a name.

LINE 2

ITEM 10. REGION AND BASIN Enter two (2) digit numbers for Region and Basin in accordance with Appendix C.

ITEM 11. CIVIL WORKS INFORMATION SYSTEM Enter official name of river or stream on which the dam is built. If stream is without name, indicate as tributary to river named, e.g., "K-OLORADO" if off stream, enter name of river plus "OFF STREAM".

ITEM 12. MARKDOWN STREAM CITY-TOWN VILLAGE Enter the nearest downstream city-town-village of such size which can be located on a general map.

ITEM 13. DISTANCE, ETC. Enter distance from dam to nearest downstream city-town-village to the nearest mile.

ITEM 14. POPULATION Enter population of city-town-village given in Item 1a1

LINE 2

ITEM 15. TYPE OF DAM Enter two (2) letter codes, in any order, to describe type of dam

ITEM 16. MATERIAL Enter two (2) letter codes that describe the purposes for which the reservoir is used. The order entered should indicate the relative decreasing importance of the project purposes

IRRIGATION	I	WATER SUPPLY	S	DEBRIS CONTROL	D
HYDROELECTRIC	H	RECREATION	R	OTHER	O
FLOOD CONTROL	C	STOCK OR SMALL		(Describe "other" in remarks)	
NAVIGATION		FARM POND	P		

ITEM 17. YEAR COMPLETED Enter year when the main dam structure was completed and ready for use. If only approximate year can be determined, note this in remarks

ITEM 18. PURPOSES Enter one (1) letter codes that describe the purposes for which the reservoir is used. The order entered should indicate the relative decreasing importance of the project purposes

ITEM 19. STRUCTURAL HEIGHT Enter, to the nearest foot, the structural height of the dam which is defined as the overall vertical distance from the lowest point of foundation surface to the top of the dam

ITEM 20. HYDRAULIC HEIGHT Enter, to the nearest foot, the hydraulic height of the dam which is defined as, the effective height of the dam with respect to the maximum storage capacity, measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier to the maximum storage elevation

Impounding Capabilities

ITEM 21. MAXIMUM Enter the acre feet for maximum storage which is defined as, the total storage space in a reservoir below the maximum plumbable water surface elevation, including any surcharge storage.

ITEM 22. NORMAL Enter the acre feet for normal storage which is defined as, the total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood control or surcharge storage

ITEM 23. CORPS OF ENGINEERS DISTRICT Enter the three character Corps of Engineers ABBR report code in which the dam is geographically located, in accordance with Appendix B, F.R. 19-2.1, Civil Works Information System, e.g., NAM, ORII, SWI, etc.

ITEM 24. OWNERSHIP Enter N, for Non-Federal (i.e., for Federal (i.e., Agencies other than the Corps of Engineers, e.g.,

Corps of Engineers)

ITEM 25. PRIVATE DAMS ON FEDERAL LAND Enter N for Yes

ITEM 26. ASSISTANCE Enter N for None, Y for Technical Assistance, B for Both Technical and Financial Assistance

ITEM 27. VERIFICATION Date the data was verified as being complete and correct. Enter date as described in Item 1a1

LINE 4

ITEM 28. REMARKS Preface remarks with the item number to which it pertains, e.g., 224. ORIGINALLY CONSTRUCTED

IN 1928. 23-SHUTTING, BASIN Only one remark line should be used for PART I remarks

6

**PART III - INVENTORY OF DAMS IN THE UNITED STATES
SUPPLEMENTARY DATA**

NED 1/14/2014 80(REST)

PART II: Item 1 IDENTITY: Enter Identity per GENERAL INSTRUCTIONS on PART I.

Navigation Locks:

LINE 5:

Item 1391 D/S HAZ: Enter the digit that most closely represents the hazard potential that could occur to the downstream (D/S) area resulting from failure or mis-operation of the dam or facilities.

HAZARD POTENTIAL:

LOSS OF LIFE

(Extent of Development)

CATEGORY

1 • Low None expected (No permanent structures for human habitation)

2 • Significant Few (No urban developments and no more than a small number of inhabitable structures)

3 • High More than few

Excessive (Extensive community, industry or agriculture)

Item 1401 CREST LENGTH: Enter, to the nearest foot, the crest length of the dam which is defined as; the total horizontal distance measured along the axis of the top of dam between abutments or ends of dam. Note that this includes spillway width, powerhouse sections, and navigation locks where they form a continuous part of the dam water retaining structure. Detached spillways, locks, and powerhouses shall not be included.

Spillway:

Item 1311 TYPE: Enter the one letter code that applies.

UNCONTROLLED = U
CONTROLLED = C

Item 1311 WIDTH: Enter to the nearest foot, the width of the spillway available for discharge when the reservoir is at its maximum designed water surface elevation.

Item 1311 MAXIMUM DISCHARGE: Enter the number of cubic feet per second which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation.

Volume of Dam:

Item 1341 VOLUME OF DAM: Enter the total number of cubic yards occupied by the materials used in the dam structure. If volume of separate materials is known, enter in remarks. Include portions of powerhouses, locks and spillways only if integral with the dam and required for structural stability.

Power Capacity:

Item 1351 INSTALLED: Enter installed capacity to one tenth (1/10) Megawatt as of the report date.
Item 1351 PROPOSED: Enter the future additional capacity proposed to one tenth (1/10) Megawatt.

Navigation Locks:

LINE 5: Item 1371 NUMBER: Enter the number of existing navigation locks for the project.

Item 1381 LENGTH: Enter to the nearest foot the length of the navigation lock.

Item 1391 WIDTH: Enter to the nearest foot the width of the navigation lock.

Item 1401 thru 1451 Enter the lengths and widths of additional locks.

LINE 6:

Item 1461 OWNER: Enter name of owner. Abbreviate as necessary.
Item 1471 ENGINEERING BY: Enter name of organization that engineered the main dam structure. Abbreviate as required.
Item 1481 CONSTRUCTION BY: Enter name of construction agency responsible for construction of main structure. Abbreviate as required.

LINE 7:

Regulatory Agency:
Item 1491 DESIGN: Enter the name of the organization other than the owner having regulatory authority or approval authority over the design of the dam
Indicate NONE.
Item 1501 CONSTRUCTION: Enter the name of the organization other than the owner having regulatory authority or inspection responsibilities over the construction of the dam. If no organization other than the owner has regulatory authority or inspection responsibilities over the construction of the dam, indicate NONE.
Item 1511 OPERATION: Enter the name of the organization other than the owner having regulatory authority, operational control, or surveillance responsibilities over the operation of the dam. If no organization other than the owner has regulatory authority, operational control or surveillance responsibilities over the operation of the dam, indicate NONE.
Item 1521 MAINTENANCE: Enter the name of the organization other than the owner having regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam. If no organization other than the owner has regulatory authority or inspection or surveillance responsibilities over the maintenance of the dam, indicate NONE.

LINE 8:

Item 1531 BY: Enter the name of the organization that performed the last safety inspection. Abbreviate as required. If no inspection has been performed enter NONE.
Item 1541 DATE: Enter the one (1) or two (2) digits for day, the first three (3) letters of the month and a two (2) digit year when the inspection was performed. If not applicable, leave blank.
Item 1551 AUTHORITY FOR INSPECTION: Enter the regulatory or inspection authority for performing the inspection indicated in Item 531, e.g., P.L. 92-367, Div. 3, Water Code, State of Calif., F.R. 110-2-100, etc.

LINE 9:

Item 1361 REMARKS: Preface remarks with the item number to which it pertains. e.g., 34.2, 500,000 c.y. conc. 475,000 c.y. carbill. Only one remarks line should be used for PART II remarks.

END

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